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THE

FOUNDRY TRADE JOURNAL

AND PATTERN-MAKER

Vol. 21. No. 210. JUNE 1919. Price SIXPENCE Net.

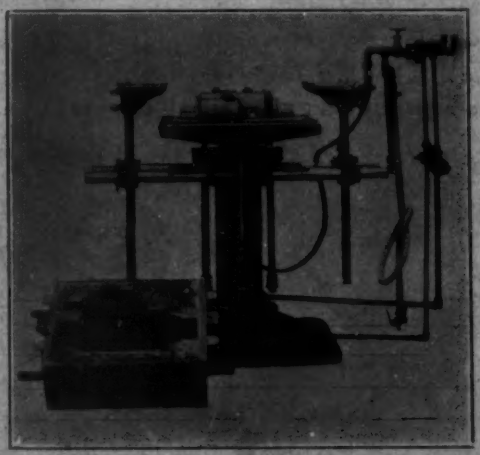
JOHN MACDONALD & SON, LTD.

ENGINEERS,

WATT STREET, MARYHILL, GLASGOW.

THE BEST TYPE OF MACHINE FOR SHELLS.

"AJAX" STRIPPING PLATE or DIRECT PATTERN DRAW JARRING MOULDING MACHINE.



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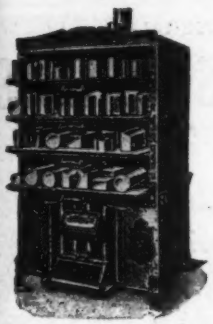

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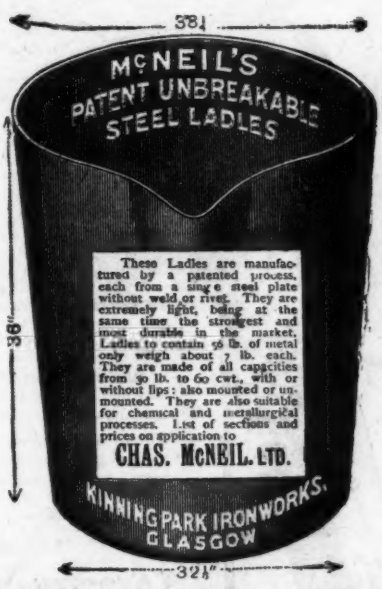
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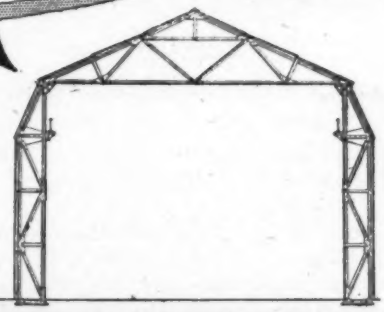

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All Dressings are Sterilized and in Cartons.

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1 „ Large Body Dressings.
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½ „ Large „ „
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1 Bottle No. 1 Eye Drops.
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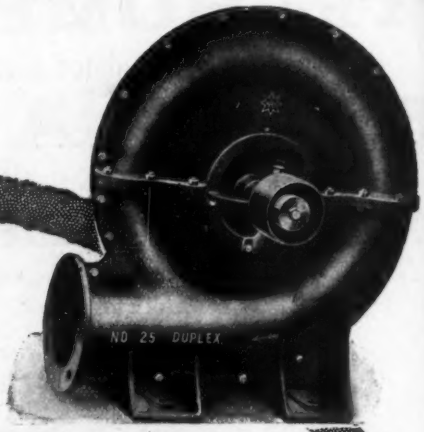

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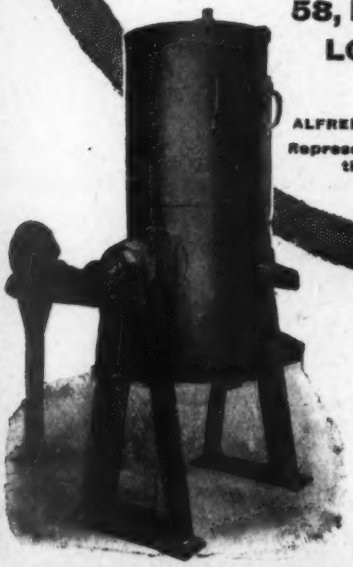

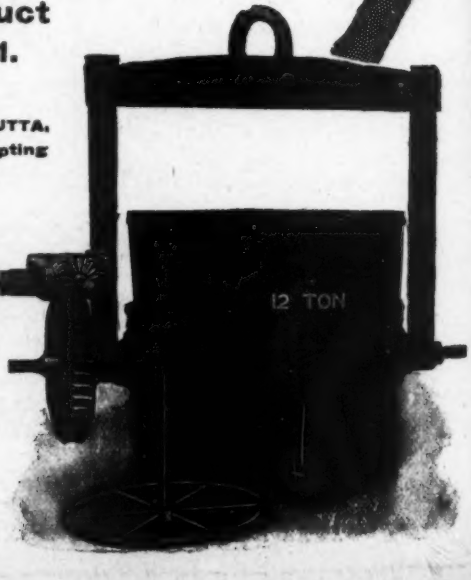

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"Rapid" Cupolas,

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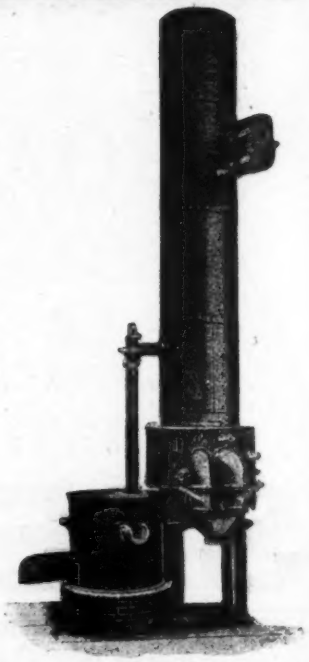

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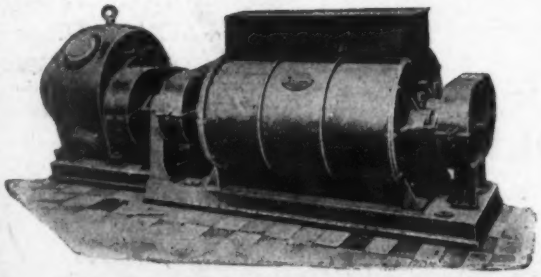

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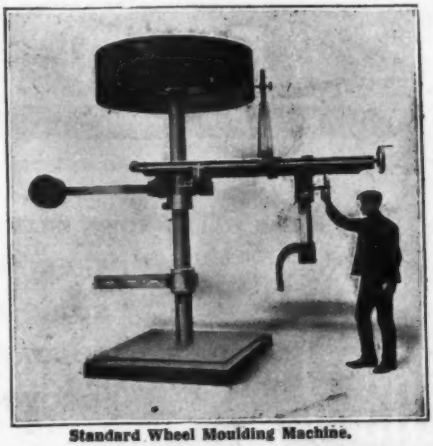

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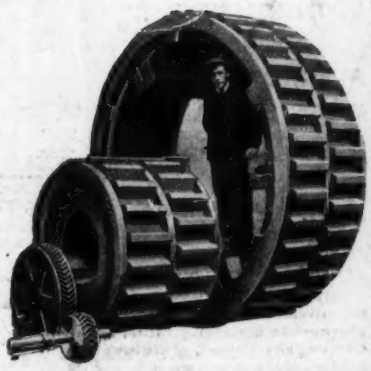
ALL IRON AND STEEL FOUNDRIES

SHOULD BE EQUIPPED WITH

STEWART WHEEL MOULDING MACHINES.

Complete Satisfaction Guaranteed



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ACCURATE. PORTABLE. CHEAP.

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It is a scientifically prepared compound, simple in use, and a guaranteed standard quality, absolutely free from sediment, makes perfect cores, which leave castings without labour and saves dressing room costs.

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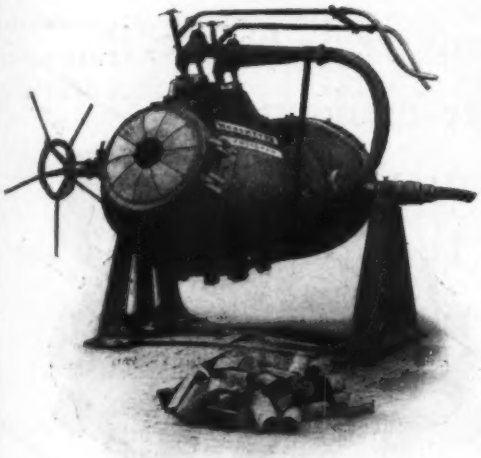

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GROUND FIRECLAY.

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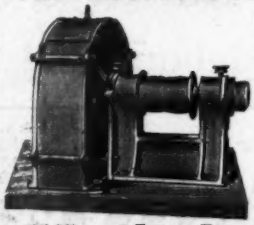

18" Mixer— 1 Ton per Hour.

Fitted with Patent Roller Bearings, Renewable Reels, Grinds, Mixes, Screens & Prepares.

OLD AND NEW FOUNDRY SANDS AT LOWEST COST.

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Made in Three Sizes—1, 3 and 6 Tons per hour capacity.

USED IN PRINCIPAL FOUNDRIES.

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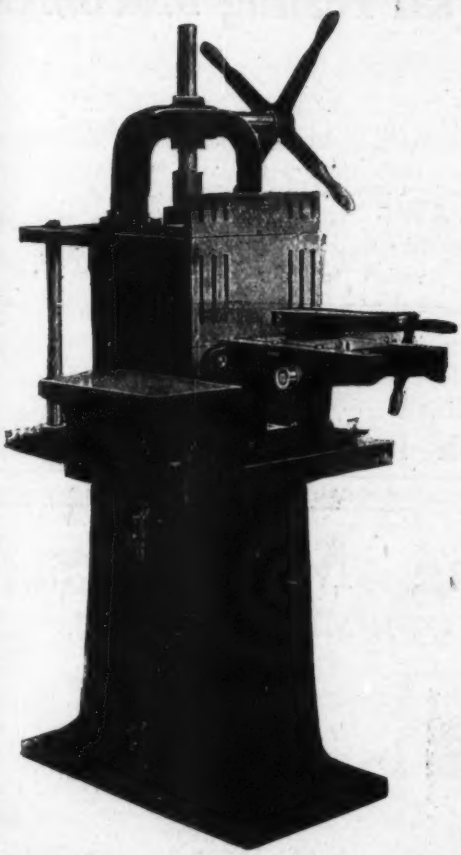
FOR THE PRODUCTION OF DEAD-SIZE DIE-CASTINGS IN TIN, LEAD & ZINC ALLOYS

These machines have proved to be a practical profit earning proposition. At great speed and low labour cost they produce castings of splendid quality and exact size ready for use without machining.



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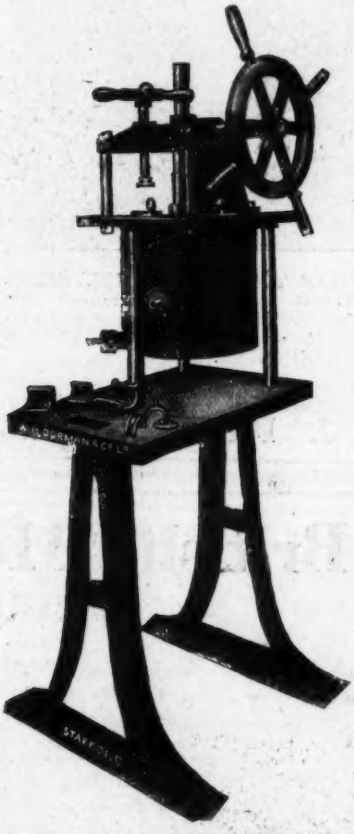

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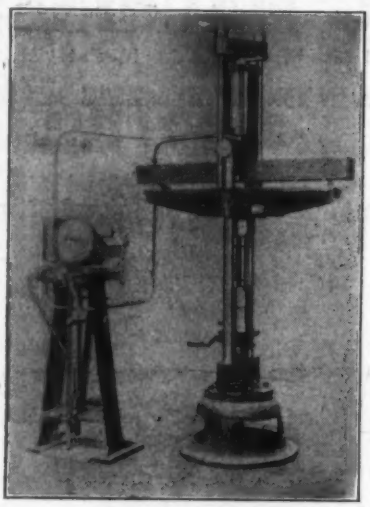

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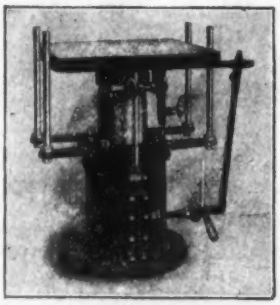

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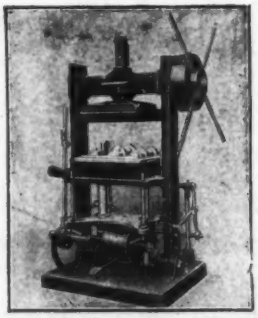

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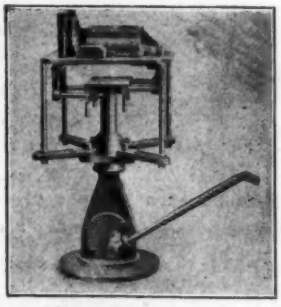

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The Foundry Trade Journal

AND PATTERN MAKER.

THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

Vol. 21. JUNE, 1919. No. 210.

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NOTES AND COMMENTS.

Open-Hearth Furnace Outputs,

There has recently been a certain amount of healthy rivalry as to the outputs being obtained from open-hearth furnaces. The Redbourn Hill Company succeeded in obtaining at their new works near Frodingham 1,103 tons 18 cwts. of mild steel in one week from a 60-ton furnace with an all-cold charge by machine. It was not so stated, but the furnace was obviously working the basic process. Messrs. Richard Thomas & Company, from a furnace rated at 50 tons, have turned out 1,040 tons in one week, also working basic practice, with cold machine charges. This furnace at one time was melting at the rate of 9.3 tons per hour, and for four weeks had an output of 3,500 tons. At the Lanarkshire Steel Company's Works at Motherwell, operating also on cold stock, 18 charges, totalling 825 tons 2 cwts., were produced in one week.

It will be observed that in the case of the Lanarkshire Steel Company the capacity of the furnace is not stated, but the bath area of the furnace is given as 317 square feet. This, of course, is the better way to give figures which are intended for comparative purposes. There is a great discrepancy between, say, a 50- or 60-ton furnace of one works and the furnace rated with a similar capacity in another, and a still greater variation sometimes between, say, the foreign 50-ton furnace and the British 50-ton. It would be interesting to know what was the hearth area of the furnace at Redbourn Hill and at the Llanelly Works of Richard Thomas & Company, Limited. Perhaps this information will be forthcoming. In addition to the hearth area a good deal depends upon the character of the charge. In order to be strictly comparative, the percentage of scrap and of pig-iron should be stated.

The main object, of course, in open-hearth furnace work, as in all others, is to obtain the maximum output, and with the minimum number of heats. This latter is an important point, so as to minimise the risk that is inevitable with all charges, such as tap holes, repairs to banks, ladles, etc. In general, the open-hearth furnaces in this country need not fear comparison with those to be found anywhere in the world, but they do not compare in size with some of the American plants. When outputs are low it is, generally speaking, due to want of facilities for rapid charging on the platform. A good manager will see that he has his raw materials available as and when required. A further failure to obtain good outputs is due to the lack of gas or to the quality of the gas. It is usually found that with an improvement in the quality or in the quantity of gas available higher outputs are more readily obtained. In the end the test of rapid driving is whether it pays, i.e., whether the life of the furnace is so seriously curtailed that the saving in one direction is offset in another.

British Refractories Research Association,

In a report submitted to the Refractories Section of the Ceramic Society, reference is made to the Swansea meeting of the Society, held in October, 1918, when a resolution was passed authorising the Council of the Refractory Materials Section to take the necessary steps for the formation of a Refractories Research Association. The following Sub-Committee was ap-

pointed to carry out the necessary details in connection with the organisation of the Association:—Sir William J. Jones, K.B.E. (Ministry of Munitions, London); Dr. J. W. Mellor (Central Laboratory, Stoke-on-Trent); Mr. B. Moore (Central Laboratory, Stoke-on-Trent); Major C. W. Thomas (E. J. & J. Pearson, Limited, Stourbridge); Messrs. G. Wink Wight (Jas. Dougall & Sons, Limited, Bonnybridge); Job Holland (Pickford, Holland & Company, Limited, Sheffield); T. Ellis (Penwyllt Dinas Silica Brick Company, Limited, Neath); H. J. C. Johnston (Leeds Fireclay Company, Limited, Leeds); H. E. Mason (Adam Mason & Sons, Limited, Norwich); and C. P. Williams (John Lysaght, Limited, Scunthorpe). It was decided that the office of the Association should be in London, and Mr. R. C. Rann was appointed Secretary.

The Committee has held several meetings and Memorandum and Articles of Association have been drawn up. The Association can be registered and start working when this present report is approved by the Ceramic Society. The essential features of the Association include the following, it being borne in mind that it is entirely and altogether a Research Association and not a trading company:—Members will consist of firms and companies engaged in the business of manufacturing, using and marketing refractory materials and products. The Association will be managed by a Council elected annually by the members. Dr. J. W. Mellor has accepted the position of Technical Director of the research work of the Association. The Committee feel that the best method of raising funds is by means of a voluntary subscription from the members, with a minimum of five guineas per year, and ranging from that sum to 50 guineas per year. It is understood that these subscriptions must be for a period of five years. It is estimated that the expenses of the Association will be in the neighbourhood of £6,000 per annum, half of which will be contributed by the Department of Scientific and Industrial Research, leaving an amount of £3,000 to be found by members of the Association. Subscriptions have already been promised from a few members amounting to over 500 guineas per annum for five years. Members will also have the right to the use of any patents or secret processes resulting from the research work carried out by the Association on nominal terms of payment as compared with firms and companies who are not members. It will be realised that no firm or company outside the Association will have any of these privileges or rights.

A preliminary programme of research work of the Association has been drawn up and is as follows:—

(1) Requirements and resources, both home and foreign, of all kinds of refractories: (*a*) Fireclays; (*b*) silica; (*c*) magnesite; (*d*) dolomite; (*e*) bauxite; (*f*) chromite; (*g*) zirconia; (*h*) graphite; (*i*) special materials such as carborundum, alundum, etc., etc.

(2) Properties and qualities of refractories: (*a*) Physical; (*b*) chemical; (*c*) mechanical.

(3) Preparation of refractories for service conditions in various industries, so as to secure uniformity of manufacture and quality

(4) Particular types of refractories most suitable for use in the following industries: (*a*) Iron and steel; (*b*) non-ferrous metals; (*c*) coke ovens; (*d*) gasworks; (*e*) chemical works; (*f*) glass works; (*g*) potteries.

THE death is announced of Mr. J. Allen, a former manager of the Roway Iron Works, Albion, West Bromwich. The deceased gentleman was associated with the Bromford Iron Works for nearly half a century, holding the position of works manager for more than thirty years. Subsequently he took over the management of the Roway Iron Works, from which position he resigned some six years ago on account of failing health, being retained, however, in an advisory capacity until his last illness.

British Foundrymen's Annual Conference.

As briefly announced in our last issue, the annual conference of the British Foundrymen's Association will be held in Liverpool on July 17, 18 and 19 next. The headquarters of the gathering will be the Royal Institution, Colquitt Street, Bold Street, Liverpool. A local commitee has been formed, and has made the necessary arrangements for a series of very interesting visits and other functions. The programme includes the following:—

Thursday, July 17.—Annual business meeting, to be held at 10 a.m. at the Royal Institution, followed by an address by the President-Elect, Mr. J. Little, and the reading and discussion of a Paper of technical interest. In the afternoon a visit will be paid to the works and shipbuilding yards of Messrs. Cammell, Laird & Company, Limited, Birkenhead, at the kind invitation of the managing director, Sir George Carter. In the evening, at 7.30, a dinner will be held at the Exchange Station Hotel.

Friday, July 18.—The meeting will be continued at the Royal Institution, at 10 a.m., when two Papers will be read and discussed. In the afternoon it is probable that visits will be paid to one of the Cunard or White Star Liners, and the village and works of Lever Bros., Limited, Port Sunlight. An excursion to Southport, and probably a river trip, will be alternative features.

Saturday, July 19.—The concluding meeting, at which a further Paper will be read, will be held at 10 a.m., at the Royal Institution, and members will make their own arrangements for the afternoon.

HEAT TREATING IN ELECTRIC FURNACES.—According to a Paper on "The Electric Furnace in the Forge Shop for the Heating of Billets for Forging, and the Heat Treating of Forgings," presented to the American Drop Forging Association by Mr. T. F. Baily, president of the Electric Furnace Company, Alliance, Ohio, there is a saving of metal due to the lack of oxidation in the electric furnace which in extreme cases of say 5 per cent. loss on steel worth £16 13s. 4d. per ton would amount to about 16s. 8d. per ton of metal heated. In addition to this the steel being in much better condition when it goes to the hammer or press due to the absence of scale, there is less danger of the dies being filled up with scale, as it is sometimes difficult even with an air draft to keep the dies entirely free. A typical running sheet on an electric furnace of 600 kw. capacity heating 3¼-in. round billets for forging into 3-in. naval shells showed the average power consumption per ton to be a little less than 260 kw.-hrs., but taking as a basis 300 kw.-hrs. per ton to cover the delays in starting up on this type of furnace and with power at ½d. per kw.-hr., the cost of heating for electricity would be 12s. 6d. a ton. It was stated that the renewals and repairs should not exceed that of a fuel fired furnace, and in fact these repairs should average much less. Against this cost per ton for electric furnace operation the fuel oil for a similar furnace operating on substantially 2 tons per hour would approximate in the average plant at least 50 gal. per ton. With a consumption of 40 gal. per ton and oil at 2½d. per gal. this charge would be at least 8s. 4d. per ton. Thus if the metal loss on a £16 steel should be over 1¼ per cent., or 4s. 2d. a ton of steel heated, the cost of electric furnace and fuel fired furnace operation would be the same with the exception of a better class of work done in the electric furnace, which would make a greater saving due to the production of more good forgings.

Bronze Statuary.

HERR B. FORSTER, of Düsseldorf, has contributed a series of interesting articles to recent issues of "Stahl und Eisen" on the casting of bronze statuary in olden and modern times, from which we abstract the following particulars. After giving a short outline of the history of the craft from pre-historic times onward, with some illustrations of bronze statuary in Rome, Florence, Nüremberg, and elsewhere, the author proceeds to state that much as we know about the bronze founders from chronicles, etc., we know very little of the origin and development of their craft. Nothing, for instance, or very little, has been handed down to us by the old craftsmen in writing as regards the composition of the metal they used, and the modern analytical chemist has therefore had to come to our rescue. Old Egyptian bronzes often contain traces of tin. The thick greyish-green patina on old Egyptian bronzes seems to point to the fact that lead must have been added to make the copper more fluid when pouring.

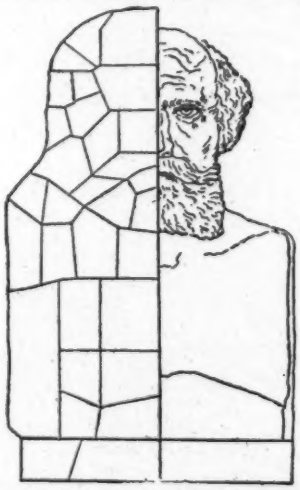


FIG. 1.—BUST IN PLASTER OF PARIS.
(One-half covered with false cores.)

Coming to Greek and Roman bronzes, it has been found that these contain less lead and more tin and zinc, while coming to still more recent times, the mediæval German bronze castings consist principally of copper alloyed with tin, and slight additions of lead or zinc. On the other hand, the French bronzes of the 15th to 18th centuries were made of a mixture of 76 to 88 parts of copper with 24 to 12 parts of zinc; they contain but rarely small admixtures of tin.

According to our author, further, the best bronze is made of 90 parts of copper and 10 parts of tin, or of 93 parts of the former and 7 parts of the latter metal. The last-named mixture has practically become the standard in Germany in recent years. For small objects and ornaments an alloy is used consisting of 88 to 92 per cent. of copper, 8 to 6 per cent. of zinc, and 4 to 2 per cent. of tin. A good bronze, according to him, must contain not less than 88 per cent. of the red metal. This is practically the lowest limit which can be used, as more liberal additions of zinc or of lead with a corresponding reduction of the copper percentage would interfere with the proper casting of the metal, and render it very much less fit for finishing or fettling work upon it, such as cleaning down and chasing. It is illusory—he says—to talk about reducing the cost by skimping the dearer copper or tin and using more of the cheaper lead or zinc. The saving will be very small, and the risk of spoiling the casting very great, especially if the object is to be cast thin. Any saving in the cost of the metal will probably be swallowed up by the cost of the extra work to be done in cleaning and dressing the casting. Analyses made of old bronze have sometimes revealed traces of iron, nickel, antimony, etc., but our author thinks these were not added purposely, but found their way accidentally into the mixture as impurities.

The manifold alloys used by the Japanese for casting their bronzes are of special interest. The oldest bronzes in Japan, too, consist merely of copper and lead, while those of the Middle Ages

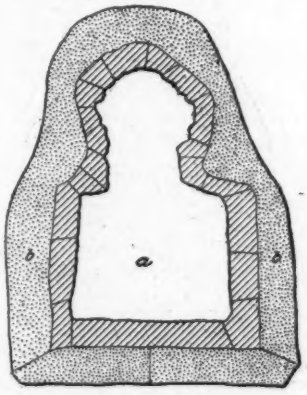


FIG. 2.—VERTICAL SECTION.
a=Core.
b=Material for bedding false cores.

are principally of a mixture of 70 per cent. of copper and 30 per cent. of zinc, with slight additions of antimony. The alloy mostly used is called "Kara-Kaué," that is "China metal," and consists of 72 to 86 per cent. of copper, 16 to 10 per cent. of lead, 4 to 7 per cent. of tin, and 6 to 2 per cent. of zinc, with the addition of 1 to 3 per cent. of iron. Besides this, they use an alloy of copper and silver, called "shibu-e-chi," the proportions in which vary between 68 and 94 per cent. of copper and between 32 and 6 per cent. of silver, and which make castings very easy to work upon. In most recent times the best Japanese bronzes are stated to be of 79 per cent. copper and 21 per cent. of mercury. The copper-silver alloys were principally used in bygone days for statues in temples, and analyses have proved that some of the Buddha statues contained even 2 to 5 per cent. of gold. Some of these figures are of gigantic size, as, for instance, the one in the temple at Nara, its

height being about 53 ft., and its width at the shoulders nearly 28 ft. Its metal weight cannot be less than 450 tons. It was cast in pieces and joined together with tin solder. It dates from the 8th century, and was badly damaged in 1570 by fire which made the solder run. It was, however, subsequently restored.

Finally, as regards the so-called French bronzes that find so much favour with connoisseurs and look like gold; as a matter of fact they are of brass, the proportions being 75 to 86 per cent. copper and 25 to 14 per cent. of zinc.

The quality of the mixture and the colour of the casting, however, do not depend entirely on the constituent metals, but also to a great extent on the process of casting, and also on the temperature of the metal at the time of pouring.

The oldest hollow castings date from the reign of Rameses II., of Egypt, about 2,000 B.C. The Japanese prepared for their bronze castings highly finished models in clay, which were used with two moulding boxes. The moulding material consisted of a mixture of clay, graphite, and coal-dust, to

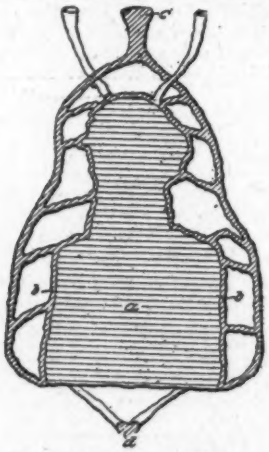


FIG. 3.—VERTICAL SECTION.
a=Core;
b=skin of wax with wax runners, etc.;
c= pouring hole;
d=outlet for molten wax.

which were added fibres of a plant, the Japanese name of which is "Karu asu." This mixture was made into a thick paste, and the clay model was carefully covered with it maintaining all the sharp outlines of the original. When one side was covered the paste was given time to dry, and then the other side was covered in the same way. The next step was to saw the clay model with the covering paste in two, to bed the two halves in clay in moulding boxes, and to remove the clay model carefully so as not to break the mould formed by the paste. For hollow castings the core was prepared on a barrel, if the castings were circular in cross section like vases, urns, etc., or it was built up, if they were of irregular section, like statues, etc.

The first artist to take a plaster cast from the figure to be cast in bronze is stated to have been the Greek Myron, who lived in the 5th century B.C., and has earned universal fame by his well-known statue of the "Disk-thrower." For the convenience of easier handling he divided his plaster casts into parts and cast separately limbs protruding from the figure, and then put the parts together afterwards. He is credited by some writers with having used the "cire-perdue" (lost-wax) process, but our author does not admit this, but agrees with the writers, who state that Myron cast his statues in the same way as did the Japanese. According to our author the "lost-wax" process was introduced by the ancient Romans. Broadly speaking, in this process the core was built up of clay and was then coated with a layer of wax of the thickness of which the metal of the casting was to be. The finishing touches were put upon the wax by the sculptor, and all details could be worked out with great precision and with remarkable sharpness; even considerable undercutting could be resorted to, which would lead to great complications in any other process. A study of the statuary found at Herculanum fully proves the fact—according to our author—that the wax process was already in use in those days. If the casting was spoilt the original model was, of course, lost, but Benvenuto Cellini got over this drawback by making first a plaster cast of the model, which he then covered with wax to which he gave all the finishing touches. Thus, in the

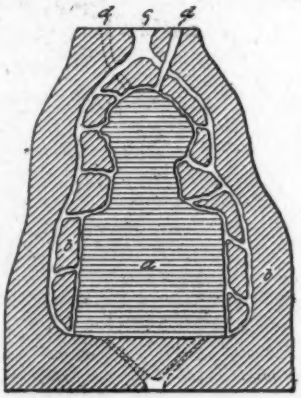


FIG. 4.—VERTICAL SECTION.
Flasks ready for pouring.

event of a failure, he had an almost finished plaster cast to fall back upon, and all his labour was not completely lost.

Our German author then proceeds to describe and illustrate what purports to have been Cellini's method of casting bronze figures. According to him a mould is made from the plaster model in false cores of each half of the model separately; the false cores were next covered with a thick layer of soft clay to keep them together and in position. The moulds thus formed were carefully removed from the model and their insides "painted" with wax. The two halves were then put together, and the space inside the wax skin filled with a liquid core which solidified. But this method at its best would have given a statue with an indifferent surface, would have destroyed all the fine finish, and eventually the outline of the model as it left the sculptor's hands; moreover, it would have given a casting smaller in size than the plaster model. It is certainly not the method, as described by Cellini himself, in his "Trattato della Sculptura," which was briefly as follows:—The figure was roughly modelled in clay, rather

smaller in size than the finished bronze statue. All over this a skin of wax was laid and worked by the sculptor with modelling tools to the required form and finish. A mixture of small broken brick, clay, and ashes was then ground fine and mixed with water to the consistency of thick paint, successive coats of which were then applied with a brush to the wax skin till a second skin was formed fitting closely into every crevice and line of the wax-coating. Soft clay was then carefully laid all over of considerable thickness to strengthen the mould till the statue with its covering looked like a shapeless mass of clay. This was next bound

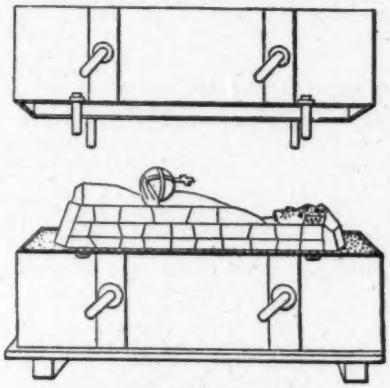


FIG. 5.—SAND PROCESS.
The figure is bedded in the lower flask and partly covered with false cores.

with iron hoops, and the whole mass was allowed to dry thoroughly. In due course it was placed in a hot oven to bake the clay both of the core and of the mould, and to melt the wax, which was allowed to run out through small holes specially made for the purpose. Thus a void was left corresponding in thickness to the layer of wax between the core and the mould, the relative positions of which were preserved by small bronze pins, which had previously been driven through the two skins (the brick-clay-ash coating and the wax). The mould was now ready and the molten bronze was poured in till it completely filled the void left by the "lost wax" between the core and the mould. After the casting being allowed to cool slowly, the mould was broken away and the core broken up and raked out through a hole in the foot or other part of the statue. The projecting ends of the small bronze pins were cut off and the whole surface of the statue was cleaned and polished, and all rough or defective places made good.

Our German author next proceeds to describe the process of casting bronze statuary in sand moulds with false cores as it was practised in Germany until Gladenbeck, in the 'eighties and 'nineties reintroduced the wax process side by side with the sand process. When the Kaiser William II. returned from his tour in Italy, and gave the well-known artist, Professor Reinhold Begas, an order to produce a public monument for Berlin of the same artistic merit as those he had seen in Rome, the famous sculptor modelled the splendid public fountain on the Schlossplatz, with such fine details in the foliage, the bodies of the animals, Tritons, etc., that the foundries were obliged to confess that they would not be able to produce the model in bronze by the sand and false core process. Hence this as well as some other public statuary in bronze were ultimately reproduced by the wax process, among them many parts of the fine monument of William the Great in Berlin, such as the realistic lions with war trophies at the four corners, the four genii, and parts of the equestrian statue of the old Emperor William I. Other parts of the monument, as the large statues representing peace and war, were cast in sand. In the modern wax process a mould is made in gelatine from the plaster model, and the making of this and the whole process of casting the bronze figure is described by our German author, but so briefly that his description would

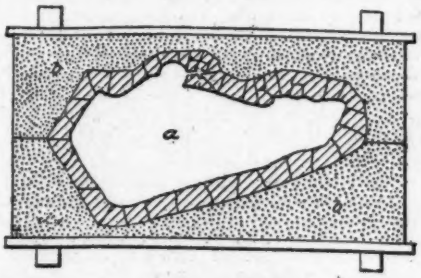


FIG. 6.—SAND PROCESS, VERTICAL SECTION.
a=Core.
b=Bedding material.

be of little use. The whole process has been described in English in great detail by Mr. Albert Toft, in his "Modelling and Sculpture," giving a full account of the various methods and processes employed in these arts. The book was published by Messrs. Seeley & Company, Limited (of 38, Great Russell Street, London, W.C.), in 1911.

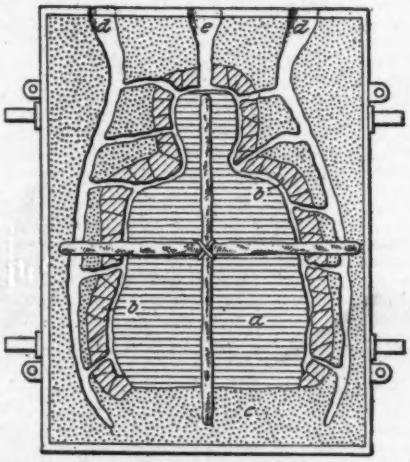


FIG. 7.—SAND PROCESS, HORIZONTAL SECTION.
a=Core pared down to give the necessary thickness of metal and suspended.
b=False cores. c=Bedding material.
d=Runners and gates. e=Vent.

We preproduce seven of the author's illustrations, which are self-explanatory. Judging by the positions of the pouring hole, vents, and the core carriers, however, Fig. 7 does not seem to represent the work as finished for the recumbent figure. As a matter of fact the hot gases are expected to rise at right angles to the direction of gravity.

The Use of X-Rays in Metallurgy.

At a joint meeting of the Faraday Society and the Röntgen Society, held in London recently, a general discussion was held on the subject of "The Examination of Materials by X-Rays." Papers were submitted bearing upon the subject, abstracts of which are appended.

Researches into the Industrial X-Ray Examination of Metals at the Laboratories of Messrs. Schneider, Le Creusot.

In a contribution bearing this title, M. E. SCHNEIDER (President of the Iron and Steel Institute) said that the apparatus used at the Creusot Works was the standard type of plant manufactured by Messrs. H. Pilon, who were the licensees for the Coolidge Tube in France. The following was a summary of the results obtained since the plant was installed :—(*a*) Researches into segregation and blow-holes. Influence of aluminium on cast steel. (*b*) Examination of steels containing different percentages of tungsten. (*c*) Examination of compound metals.

(*a*) The method was first of all applied to the investigation of blow-holes in cast steel. Steel plates (railway fishplates 23 mm. thick) were cast in sand moulds without any special precaution being taken. The photographs showed a number of white spots, each of which represented a blow-hole. Two fishplates exhibited very different forms of blow-holes. In one they were near the surface and stretched out in a direction perpendicular to the walls of the mould. In the other the blow-holes were central and very large in volume. Radiographs were also taken of two fishplates made at the same time as the others, with steel from the same cast, in moulds made from the same sand and dried under the same conditions. But at the moment of casting the plates, 37.5 grammes of aluminium for each kilogramme of steel was added in the case of one, and 75 grammes per 100 kilogrammes weight of steel in the case of the other. The two photographs showed a diminution in the number and size of the blow-holes when the quantity of aluminium added on casting was increased, and also showed clearly the action of this metal in deoxidising the molten steel. By radiographing test pieces containing increasing quantities of aluminium it should thus be possible to determine, for a given casting, the minimum quantity of aluminium to be added to eliminate central blow-holes.

In the case of a cast-steel bracket of a gun wagon, the radiograph showed a clearly defined blow-hole which compromised the solidity and strength of the bracket. This blow-hole was due to defective casting. By changing the method of casting, brackets were obtained in which this blow-hole was not present.

When a steel casting was made, and it was desired to ascertain whether blow-holes formed in the metal when cold, a small piece of extra metal about 20 to 30 mm. thick was cast in one with the main casting, this extra piece being examined under the X-rays. When a new casting was being made in which, owing to the method of casting adopted, there was reason to suspect the existence of a defect at a particular point, this particular part was radiographed to ascertain whether the metal was sound. This might lead to a change being made in the method of casting. Unfortunately, there were limitations to this method, owing to the lack of penetration of the X-rays. It was not possible to penetrate a thickness of more than 45 mm. of ordinary steel, and even for this thickness the time of exposure was considerable.

(*b*) As regards tool steel, when the percentage of tungsten (which is of high atomic weight, viz., 182) was high, the plates were not so permeable to the X-rays as when this percentage was low. When suitable illumination was employed these differences showed up much more clearly on the negatives than on the positives. Thus three carbon steels, containing 0.6, 0.9, and 1.15 per cent of carbon respectively, gave a radiograph in which were clearly observable the differences in opacity corresponding to these percentages. It would appear possible, then, to apply radiography for the purpose of a rapid analysis in particular cases. If, for instance, carbon steel bars had been mixed up inadvertently with tungsten steel bars, they could be sorted out speedily by radiography.

In stating his conclusions, the author said that in the present state of our knowledge of X-rays and their production, the application of radiometallography enabled a visual examination to be made of ordinary steels, provided their thickness did not exceed 40 to 45 mm. This limiting thickness was reduced when the steel contained at least one constituent of higher atomic weight. It would be of inestimable value in metallurgy if ingots of 20 cm. thickness and upwards could be radiographed; but unfortunately we had not yet reached that stage.

X-Ray Examination as Applied to the Metallurgy of Steel.

A contribution by SIR ROBERT HADFIELD, BART., MR. S. A. MAIN, B.Sc., and MR. J. BROOKSBANK, B.Sc., was in the following terms :—

(1) The possibilities of X-ray examination in steel manufacture will be readily apparent. The means which it provides for enabling the metallurgist to see the interior of steel castings and forgings, and thus to diagnose and localise the diseases to which steel is subject, must prove of considerable benefit.

(2) The chief difficulty hitherto has been the limited thickness of metal which could be penetrated, but considerable strides have been made within the last year or two in this direction. Thicknesses up to 4 in. are now said to have been successfully radiographed.

(3) It is obvious that to be of service it must be possible to examine articles of a practical size; otherwise the chief advantage of such a method of examination is lost, namely, its non-destructive character. A few years ago, and even now with the larger articles, it was necessary in order to examine a casting to cut out a section to obtain a radiograph, thus destroying the article for practical purposes. While this served its purpose for research examination, it still left the wider application, that is, for inspection of articles intended for service, untouched. The advantages of applying the method to the routine examination of special steel castings and forgings in the course of their manufacture, to ensure their being thoroughly sound, will be at once apparent.

(4) X-ray examination need not necessarily be confined to the steel products themselves, but also to materials used by the steel manufacturer; another application which suggests itself is the examination of welds.

(5) The question of internal defects has always been a bugbear. In the case of an habitual tendency, such as the well-known "pipe" in ingots, this usually reproduces itself under similar conditions of manufacture, and can be controlled by the cutting up and examination of an individual ingot out of a lot, this forming a criterion of the whole. Many of the defects met with are, however, of a casual nature, and the use of X-rays will help in these cases by individual examination and elimination of the defective articles.

(6) Apart from the mere detection of defects, it is a distinct advantage to have these defects visualised to the eye, and the perspective view presented by a stereoscopic radiograph carries much more information to the mind as to the nature of the defect than the alternative method of fracturing the article through the defect, which only presents a sectional view.

(7) The routine operation of X-ray examination will

be much facilitated if the necessity for photographing can be avoided; that is, if articles may be examined by the use of a fluorescent screen. This would very much increase the rate of examination and, after all, in inspection work, the majority of the articles are expected to be free from defects, and, therefore, no permanent record is required. In those cases where a permanent record is required, the particular articles may, of course, be put on one side for the purpose.

(8) A further point is that of expense. Present apparatus for the purpose is costly and delicate, and its operation of a rather expert nature to be applied to routine purposes.

(9) It must be borne in mind that in the present state of the science, X-ray examination does not magnify defects, so that its utility is limited to those defects which are of a size within the visibility of the naked eye. Many of the defects in steel arise from microscopic causes, and these must still rely for their elucidation on the valuable work covered by micrography.

(10) Quite apart from the question of defects in steel is the very valuable field in theoretical metallurgy, opened up by Professor W. H. Bragg and followed with great ability by Professor A. W. Hull, applied to the atomic and crystalline structure of metals. Whilst this subject is rather a matter for the research laboratory, it should eventually give positive evidence on vexed questions concerned with the atomic structure, such, for example, as allotrophy, on which, hitherto, it has only been possible to theorise.

(11) A still further application for X-rays in metallurgy, which may perhaps be mentioned, is the analysis of steels. Chemical methods are so well established, and on the whole so satisfactory, that X-ray examination can hardly take their place. Still, the subject is one which may well be worked upon both for its own sake and the additional view-point which is provides as to the constitution of steels.

Radiographic Examination of Carbon Electrodes Used in Electric Steel Making Furnaces.

Sir Robert Hadfield, Bart., in a contribution under this heading, said that, in view of the trouble experienced with electrodes in electric steel-making furnaces, due to various causes, but principally to fracture in use or in handling, it was thought radiographic examination might help to show internal causes accounting for their behaviour. These electrodes varied in size up to no less than 20 in. in diameter, and a great deal depended on their good behaviour in service. Fracture, if the broken end of the electrode fell into the steel bath, might be disastrous to a whole cast of steel, and, in any case, gave rise to delays which were objectionable both on the score of consumption of electric power and difficulty in controlling the changing composition of the steel.

These carbon electrodes, continued the author, are of two kinds—namely, those known as amorphous, and graphite electrodes. The former give most trouble, and, being also more heterogeneous in structure than graphite electrodes, are more suitable for radiographic examination. The data in this paper, therefore, refer more particularly to these amorphous electrodes, though specimens of graphite electrodes are also included. The method by which amorphous electrodes are produced is roughly as follows, though in detail it is naturally more complicated. A highly carbonaceous material, such as retort carbon, anthracite or petroleum coke, or mixture of these, is crushed and mixed with binders such as pitch and tar. The plastic mixture is then moulded under pressure, either in cylindrical containers or by extrusion, and the moulded electrodes baked into a solid mass in furnaces under conditions which prevent oxidation. A number of electrodes obtained from different makers were therefore selected for examination. As an indication of the general purity of the specimens, the amount of ash residue after combustion was determined. Measurements were also made of the specific gravity, both apparent and real, the relative values of the two giving the porosity, and a record taken of the general character of the specimens. These data are given in Table I. Transverse sections were cut from these electrodes, the sections being 1 in. in thickness. These were sent to Messrs. H. W. Cox & Company, 159, Great Portland Street, London, W., who radiographed them and prepared stereoscopic negatives.

In the first set of radiographs the specimens were exposed by themselves, but for the second set small boxes of some of the materials used in electrode manufacture, such as retort carbon, pitch and anthracite, were included with the object of identifying the character of the grains seen in the electrode sections. Positive plates were printed by contact from the negatives, and examined in an X-ray stereoscope made at the Hecla Works of Hadfields, Limited. These showed in a very clear manner the structure of the various electrodes so far as it was rendered visible by the X-rays, and in a much clearer manner than was possible in photographic reproductions. It cannot be said, however, that much further light is thrown on the behaviour of electrodes as the result of the radiographic examination of this miscellaneous selection.

Table I.

Diameter.	Analysis. Ash.	Analysis. Carbon (by diff.)	Specific gravity. Actual.	Specific gravity. Apparent.	Porosity.
In.	Per cent.	Per cent.			Per cent.
		1st Set.			
A 14	5.2	94.8	2.22	1.47	33.8
B 18	4.2	95.8	1.80	1.59	11.5
C 18	15.8	84.2	1.79	1.59	11.0
D 18	3.4	96.6	2.09	1.61	22.9
		2nd Set.			
E 14	3.2	96.8	2.07	1.59	23.1
F 16½	4.5	95.5	1.71	1.65	3.5
G 17	4.7	95.3	1.92	1.55	19.5
H 20	4.4	95.6	2.19	1.62	26.1

A Coked ground mass containing rather small lumps of anthracite.
B Coked ground mass containing dull rather coarse lumps like anthracite.
C Coked ground mass containing rather small lumps of anthracite
D Like C, but larger lumps of anthracite.
E Like C.
F Mostly small shiny grains, not much ground mass visible.
G Coked ground mass, moderately coarse lumps of anthracite.
H Anthracite very small in size and amount.

Comparison of the structure with the behaviour of these electrodes in service shows that coarse structure is apparently not detrimental to good behaviour (that is, freedom from fracture in service), as the best electrode "C" in this respect has certainly a very coarse structure, while at the same time the worst, "H," also has a coarse structure. The specimen with the finest structure, "F," is of only average quality.

Two specimens taken from graphite electrodes were included. These gave perfectly structureless radiographs, though a crack showed up very clearly.

Probably the best use of radiographic examination might be made in connection with systematic experiments on electrode manufacture, where variations of composition, baking temperature, etc., would be carried out step by step. It is possible that differences in structure might then be traced in the various radiographs obtained and connected with the variations in manufacture. The peculiar character of certain grains might, for example, be explained. From the appearance of these grains it would seem that they are in process of assimilation into the matrix of the electrode, and, if this is the case, such a systematic research would no doubt show this assimilation in progressive stages. It may be added that this radiographic examination of the carbon electrodes proved of considerable service to Messrs. Hadfields, Limited, Sheffield.

Detection of Hair Cracks in Steel by X-Rays.

In a note under this heading, Lieut.-Colonel C. F. Jenkin said that considerable claims had recently

been made for X-rays as detectors of hidden flaws in steel. The only flaws concerning which he was interested were the hair cracks which had given considerable trouble in aero-engine crank shafts, and there seemed no likelihood that X-rays could reveal them, but he was persuaded to test the matter practically. Samples were examined by the X-ray apparatus by the experts who were pushing the process. They were pieces cut from crank-shafts with large and relatively obvious flaws, but no trace of defects was shown by the X-rays. One sample, about 2 cm. thick, was cracked right through the thickness for a length of about 6 cm., but there was no evidence of the crack in the radiograph. If such large flaws could not be detected, it was obvious that the method was useless for finding hair cracks.

Discussion.

In the general discussion which followed, Dr. C. A. Edwards (Manchester University) drew attention to the very great bearing which this work would have upon the future of all metallurgy.

Captain Jackson (Admiralty Inspector of Steel in Sheffield) said the application of X-rays would enable them to check whether there were internal flaws in the material without it being necessary to keep any permanent record of the observations, except in cases of defect or suspicion of defect. He almost hoped that they would be able to determine whether there were flaws by merely passing the material before some form of screen, and, by the shadow on the other side, to reject or pass it straight away. One of the troubles with heavy gun forgings was the question of small defects in the steel, particularly nickel-chrome steel. With this steel there were typical flaws which did not always appear on the surface. Perhaps it was found that in turning a gun forging certain flaws appeared. With further turning they disappeared, but other flaws made their appearance. When they came to the finished gun forging, perhaps there were no visible flaws, and then the inspectors had to make up their minds whether there were any flaws in the forging or not. As they could not see any, they had to say there were none. In order, however, to accept forgings under these conditions, and so as not to run any risk in doing so, it was necessary to have a large margin of safety in the design, whereas, if they could be perfectly certain that there were no flaws, that margin could be reduced. Consequently, if X-ray examination could be developed so that it was possible to thoroughly examine thick steel forgings to ascertain whether there were any flaws in them or not, it would be of great practical advantage in the development of ordnance. There was another direction in which such a method would be valuable. During the times of pressure through which we had recently passed, the assembling and inspection of fuses had to be carried on with great rapidity, and there was always the possibility of important components being left out. In two particular instances which came under his notice it was wanted to know whether components had been omitted from certain fuses, and X-ray examination would have enabled him to have examined the fuses without the trouble of having them taken to pieces to find out, and then having to reassemble them again.

Mr. S. A. Pollock (representing the Postmaster-General) said that the Post Office twenty years ago appreciated the possibility of using X-rays for the examination of soft materials—for instance, gutta-percha for submarine cables. X-ray examination had been used with great success. He was of course referring to the old-fashioned method of examining such materials by means of X-rays. The Post Office had not yet used the method for examining steels, which was a new development. It was sometimes found that after a lead-sheathed cable had been in the ground for two or three years—and such cables often involved a capital expenditure of £100,000—the lead was found to be defective, owing either to the effects of expansion or contraction. The sheath was found to have opened, and the cable had to be drawn out and replaced. Metallography had been found very useful in detecting such defects before the cable was laid. The temperature of the lead in the press was often responsible for failure. The Post Office was also very much interested in ascertaining why stainless steel resisted oxidation, and whether it would resist nitric acid and hydrochloric acid. They would like to know whether X-ray examination would show the reasons for this non-corrodibility, because this matter was of very great importance in the manufacture of submarine cables. A submarine cable with ordinary material had been reckoned as having a life of 20 years, this being fixed by the corrosion of the sheath. He was also interested in the power required to examine thick castings of metal or metal made in large forms. It seemed a very remarkable thing that there should be penetration through such thicknesses, and showing relatively small defects.

Beehive *v.* Patent Coke.

The question of which is the best class of coke for use in the iron and steel industry was among those discussed at the recent meeting of the Midland Section of the Coke Oven Managers' Association, held at Barnsley.

Mr. T. B. Smith (Stocksbridge) said the firm with which he was connected had crucible steel works as well as coke ovens. The coke produced in their patent ovens was quite as hard, as good in appearance, and as low in sulphur as the coke which the firm obtained from beehive plants, yet they could not use the former on account of its shape. The beehive coke was in the form of long needles, and could be got into the crucibles far more easily than lumps of patent coke, which were generally of a cubic form. He did not think the patent ovens would ever overcome this difficulty. Owing to the increased production of open-hearth steel, the demand for coke for crucible steel was not so great as it had been formerly.

Mr. C. P. Finn (Hemsworth) said he did not think it was strictly correct to speak of the preference of iron smelters for beehive coke. He should say that very few blast furnaces were using that class of coke, unless they were older plants, working cold blast. In crucible steel melting, however, the preference for beehive did exist among certain melters or melting firms. It was due partly to the high quality of some of the beehive coke supplied, which was better than the majority of patent cokes. To satisfy the people who were genuinely out to try if they could use patent coke, they must produce a material which was low in sulphur and ash, and which did not fuse or clinker at the temperature of the furnaces. Another point was the texture of the coke. The texture of patent coke, especially of that made by stamping, was too dense for most furnaces where steel was melted in crucibles. There was no doubt that, if care were exercised in selecting coke of a suitable texture, patent coke could be used for steel-melting just as well as beehive.

STELLITE.—The "Revue de Métallurgie" publishes an interesting article on "Stellite," by L. Guillet and H. Godfroid. This alloy was discovered in 1899 by Mr. Haynes, and its use for cutting tools is becoming widespread, notwithstanding its high price. It is a complex alloy of carbon, cobalt, chromium, tungsten, and sometimes molybdenum. Stellite containing more than 10 per cent. chromium is very hard and is filed only with difficulty. The two French investigators draw the conclusion that stellite is a most interesting alloy in that it may be used without any special treatment, and even under these conditions gives better results than the best high speed steels actually on the market, at least used on the materials mentioned (medium carbon steel, quenched and tempered, and on grey cast-iron). It has, however, the inconveniences of being heterogeneous, and the results obtained are not always constant.

Recent Developments in Refractories.

In his recent series of lectures on refractories, delivered at Newcastle, Dr. Mellor gave utterance to many suggestive and valuable observations, some of the more interesting of which are included in the following :—

The composition of fireclay may be represented by the ordinary ultimate analysis, by the so-called rational analysis, or by a formula. The first of these is obtained by the ordinary processes of chemical analysis, the second is obtained by special procedure which is less rational than the name implies, or better by calculation from the ultimate analysis, and the third is also derived from the ultimate analysis. The chief interest in representing clays by formulæ is connected with attempts, like that of Ludwig, to establish relations between composition and refractoriness (or its converse, fusibility). For this purpose Ludwig took the alumina in the clay as the unit, and expressed the silica and the fluxing oxides in corresponding molecular proportions. By treating the higher Seger cone compositions in the same way, marking the molecular proportions (taking the alumina as unity) of silica as abscissæ, and the total fluxing oxides as ordinates (along the first upright line), and then connecting the corresponding points for each cone by an oblique straight line, a series of isotectic lines for the fusion of fireclays, is obtained. A clay, of which the composition can be expressed by a similar formula, can be represented by a point on the diagram, and its position relative to the isotectic lines of the cones, should indicate its fusibility. On account of the assumptions necessarily involved in the application of Ludwig's chart, Dr. Mellor, like most other competent scientific investigators and thinkers, held at the outset a poor opinion of it. But he was somewhat surprised to find that on putting nearly 70 British clays to the test, only about three of them failed to agree with observation. This is the more remarkable when it is remembered that by excessively fine grinding the refractoriness of a clay can be lowered two or even more cones, but as so large a proportion of the clays fit in with the scheme, the deviations of natural clays from the average grain size are evidently not great enough to affect the result, at any rate so far as high-grade clays are concerned. The arguments are not applicable with low-grade clays.

For mixtures of three different substances, the proportions of all of which may vary, the softening temperatures (or fusing points, if they have definite fusing points) may be represented in a somewhat similar manner on a triangular chart—as, for instance, ternary mixtures of clay, felspar, and quarts.

Clays which have not been washed—and few fireclays are ever washed—have a grain-size which is determined largely by the non-argillaceous constituents. A well weathered clay apparently has its particles separated by films of water. Ordinarily the hard clays are ground, and the particles always remain in lumps of a size depending on the manner of grinding. The lumps are known as knaps, and are clots or aggregates of the finer grains of clay. Their subsequent behaviour in the brick is similar to that of badly-fired grog. The clay is not doing its best work when it is ground. The knaps are gradually broken down by water when the clay is left to stand for a few weeks in a wet state. Clays prepared in this way are easily moulded and worked, but they do not dry satisfactorily owing to unavoidable inequalities. To facilitate reasonably rapid drying of plastic clays, a non-plastic opening material is therefore added, usually grog, and the grain size of the grog should be adapted to the special purpose of the refractory.

To get the soundest and best possible fireclay brick of a given texture, it is necessary to use grog which has attained its maximum shrinkage, and to take out of the bricks during the burning over 99 per cent. of the possible fire shrinkage. A practical test for finding if a brick has been adequately fired is to heat one half of a brick in a furnace in which similar bricks are used, and then to compare the result with the half which has not been refired. In the standard test the brick is heated for a specified time at a specified temperature, and condemned if the after-contraction exceeds the specified minimum. The effect of the gas engineer's specification on commercial bricks has been to lower the average after contraction from about 2 to about ¾ per cent.

Alumina, when heated, has its specific gravity increased from about 2.8 at 600 deg. to about 3.9 at 1,200 deg. C., with corresponding contraction of nearly 30 per cent. The change is an exothermal reaction, heat being evolved after the temperature has been raised to about 1,000 deg. C. Much the same thing happens on heating bauxite, which consists mainly of alumina with various proportions of iron oxide, titanic oxide, silica, etc. The tremendous contraction of bauxite or alumina bricks presents serious difficulty to manufacturers, the products being liable to crack and become distorted, and under ordinary firing conditions it is not easy to ensure completion of the reaction. The subsequent contraction of inadequately shrunk bauxite or alumina firebricks has so often been attended with serious results that such bricks have been condemned by both maker and user, and in fact they have never had a fair chance to show their capabilities. When bauxite is thoroughly shrunk by previous fusion, as in electric furnaces, excellent refractories can be made of it, but they are expensive. In France, fused bauxite is said to be produced economically by the Lecesne process, its trade name being corindite.

Magnesia is also changed by heat into a form which has a higher specific gravity, and the presence of ferric oxide is known to accelerate this change. There is evidence that the presence of iron oxide in a certain form can hasten the converse change on heating quartz to produce a low specific gravity form of silica, so that in manufacturing silica bricks there may be instead of 30 per cent. conversion, perhaps 60 per cent. conversion. Some excellent bricks were made in South Wales with silica rock containing 5 per cent. of ferric oxide, and one furnace manager declared they were the best he ever had.

Dr. Mellor has met with silica bricks made with a little carbonaceous clay in which, contrary to ordinary experience, the conversion had proceeded faster in the interior than on the exterior.

As regards bonding material for silica bricks, Dr. Mellor prefers a highly plastic and tenacious clay bond rather than a lime bond, though the latter is probably more generally used.

Fine grinding facilitates the subsequent conversion of quartz into a low specific gravity form of silica. The conversion apparently proceeds inwards from the surface of each grain, as well as of the brick as a whole. The finer the grain the greater the proportion of bond, and as the bond is the weakest part of a silica brick in actual use, the advantage of rapid conversion is opposed by the disadvantage of greater bonded surface.

For resisting the corrosive and cutting action of slags, the texture of a refractory must be as fine-grained as practicable. Dust impinging on brickwork exerts both erosive and corrosive action. The penetration of firebricks by some dusts is curious. With dusts of oxides of iron, copper, and zinc in a reducing atmosphere, the penetration may amount to an inch in about two hours. Some evidence has been obtained of volatilisation of these metals at astonishingly low temperatures—copper at 600 deg., iron at 1,100 deg. C.—and Dr. Mellor believes the metals

penetrate the refractory as vapours. Here, also, a fine-grained texture is best for resisting penetration, as well as attack by the dust.

Such volatilisation may possibly have some bearing on certain not well understood metallurgical reactions.

Ferruginous dusts in reducing atmospheres are characterised by rapid slagging of silica or fireclay refractories. Thus a steady drip of slag takes place on the bottoms of retorts heated by producer gas from a coal with ferruginous ash.

In the case of salty coals, salt vapour rapidly attacks both silica and fireclay refractories. The same reaction is made use of for salt-glazing drain pipes, etc. Experience indicates that bricks having a molecular ratio alumina to silica less than 1 : 3.5 give the best results, as in the case of a good resister containing 63 per cent. silica ($63 \div 60 = 1.05$) and 30 per cent. alumina ($30 \div 103 = 0.29$).

A minor point elucidated was the desirability of mixing wet grog rather than dry grog with wet clay, the wet grog seeming to get a better grip of the other materials. When wet clay is dabbed on a dry plaster slab, a film of dried clay is soon formed in contact with the plaster, and the clay drops off; if the plaster slab be wet, no dried film is formed, and the clay sticks fast. The behaviour of wet and dry grog is similar. This later affects the tensile strength, the crushing strength, and contraction of the brick, all in favour of soaked grog.

Materials of a porous open texture are usually employed for withstanding abrupt changes of temperature, subject to the necessity of preserving sufficient toughness, as in the case of muffles, muffle quarries, zinc retorts, gas retorts, etc. The necessity of limiting the permeability to gases also tends to restrict porosity. The low thermal conductivity of highly porous materials also makes a porous structure unsuitable for low-temperature muffles and retorts. Dr. Mellor, however, holds the somewhat unorthodox view that at high furnace temperatures a highly porous structure favours the conductivity of heat. He considers that the effects of radiation and convection across the pore spaces are by no means negligible, but the question can only be settled by observation. Work in this direction was well in hand before the war, but had to be suspended. It has now been resumed, and it is hoped to attain decisive results before long. The point is of great importance in heat engineering.

The consumer of refractories has to consider carefully the prevailing conditions in the different parts of furnaces, so as to select the most suitable firebricks for the several parts. Thus in the lining of a blast furnace, the bricks near the top, though not exposed to very high temperatures, have to withstand abrasion, impact, and changes of temperature. These bricks are liable to spalling and disintegration, due (it is supposed) to deposition of carbon formed by reactions between furnace gases and iron oxide in the bricks, especially when the iron oxide occurs in nodules or patches. The bricks should not only be uniform, but close and compact, such bricks being usually tough and less permeable to gases. The temperature increases in descending the furnace. The upper parts of the lining normally receive some protection from a surface film of carbon, but friction of the descending charge and impact of fine solid particles driven by the blast may produce erosion. The bricks in the mid zone are also exposed to the slagging effects of salt particles and other basic fluxes from the coke, etc., but there are no abrupt temperature changes, so a close-textured compact brick is desirable for this region. The conditions prevailing in the hearth and bosh need very special bricks to withstand high temperature, the scouring action of highly basic molten slag, and a rather heavy load; the volume changes should be small and the joints particularly good, since the bricks must be tight without leakage; there is comparatively little abrasion. The stove bricks should have a high thermal capacity, so as to absorb and give up again as much heat as possible, and they should withstand the sand-blasting action of flue dust.

The specific heat of firebricks increases rapidly with rise of temperature, so that in a temperature t deg. up to 1,300 deg., the specific heat is $0.193 + 00006\ t$.

Moulding Large Pan or Dish Open Sand.

By C. Thomas.

The sketches show how a large pan or dish with bevel sides and ends may be made open sand. Sketches Figs. 2 and 3 are part plan and section of the casting required. Sketch Fig. 1 shows the pattern. This pattern is made in seven pieces, comprising one side-piece, two ends and four corner pieces. The corner pieces are made to take up three or four inches of the sides and ends.

The sketch at A shows a frame on which are screwed four bevel pieces of wood marked B. This frame is used to set the several pieces of pattern in the sand. The side and ends have, at an equal distance from each end, wood pegs projecting, and the frame has holes in it to correspond. To mould the pattern, the side-piece and one end are placed in the sand, and the frame with the bevel pieces attached placed over the pegs. The

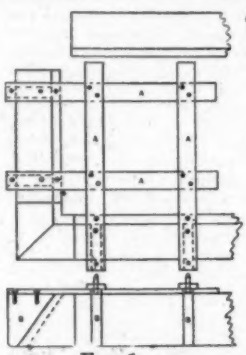
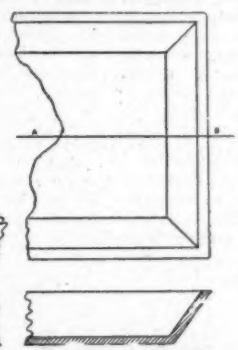


FIG. 1.



FIGS. 2 AND 3.

side and end are now rammed up on the inside to the bevel blocks on the frame. The corner piece is placed in position and rammed on the outside up to the end and side.

The other end is put in the sand and the frame placed on the pegs at this end of the tray. This end is served exactly the same as the other. We have now one side, two ends and two corner pieces in their correct position. The frame being removed the side and two corner pieces are rammed to the top both inside and outside, and the thickness of the bottom strickled about half-way across by means of a strickle worked on each end.

The side piece is now drawn from the sand and placed in the sand on the opposite side, the frame again being used on this side to determine the correct position and bevel. The two remaining corners are put in, the frame removed, and the side corners and ends rammed to the top. After the other half of the bottom has been strickled, the side and ends are drawn from the sand, the corner pieces being left until the last. Any provision that is required for lifting purposes may be put on the sides by means of placing a separate core containing this up to the side when ramming up.

Notes on Cupola Practice.*

By J. Bagley.

Of all the plant of the iron foundry the cupola holds the position of first importance, as the success of the whole works depends upon the successful working of its cupola. Despite its many drawbacks, the rapidity with which it can be lighted up and heated up to melting point, the readiness with which it can be repaired, together with its low cost of maintenance and the ease with which fair commercial results can be obtained, have contributed to maintain it in the position it still holds as the most important means in use for melting iron. Before anyone can expect to obtain satisfactory results from his cupola he must be in entire agreement with the theory of its designer. Several theories have been put forward with good results, but each one is seeking the same end—namely, to obtain the maximum heat from the combustion of the fuel in the minimum of time with little or no change in the composition of the resultant metal.

The construction of a cupola appears simple, yet its several dimensions must be related one to the other if economy is to be secured. When installing a cupola the questions to be answered are:—(1) How much metal will be required to be melted each blow or each day? (2) How many cwts. or tons of metal will be required per hour? (3) What size of cupola shall be installed?

Of course, one in excess of requirements is always advisable, because if the full capacity is not needed at once it can be lined up to the capacity to suit requirements. It is claimed by some writers that cupolas of the following diameters, melting continuously for three or more hours, will melt at an average rate of:—

Per hour. Tons.	Cwts.	Diameter in Inches.
1	5	20
1	17	24
3	0	30
4	5	36
6	1	43
7	10	48
9	1	54
11	15	60
12	11	62
14	15	66

There have been many tables given which do not agree with this; but I think that when the cupola diameter was measured, it has been measured at the tuyers; and it is never stated whether the size is average of the full time of the blow or only for a period. The above figures are the average of a four-hour blow, and the cupola was measured at a point between the top of the tuyeres and 4 ft. above. The cupola in ordinary use is in its essentials a blast furnace on a small scale, air being supplied by a blower or a fan, and consists of a boiler-plate shell 3-16 to ¼ of an inch thick, and single-riveted, resting on a cast-iron base plate, which is supported on a brick or concrete platform of convenient height for filling the ladles.

The breast plate (if solid bottom), tapping hole, and charging door are cut out and strengthened, a strong flange is riveed on the botton, and a few tiers of angle-iron are riveted inside to stay the lining—in place of these some use cast iron brick shelves and bolt them to the shell—and then the tuyere arrangements are marked out. The lining should be two courses of firebrick, the inner course being of high-quality refractory firebrick. At about 2 ft. from the charging door, in place of the firebrick, it has been found advisable to use cast-iron hollow bricks, built into position. If these are used, they will be found both economical and durable, as they resist the wear and tear of the charges, coming in contact with them better than do the firebricks. The iron bricks should conform to the radius of the shell, and, as each course is laid on, the hollow should be filled with fire-brick chips mixed with ganister or fireclay (ganister by preference). Above the charging-door and up the stack, a lower grade of firebrick may be used.

With reference to the internal shape of the cupola, the parallel shaft is regarded by most men as the most efficient, but the writer prefers the walls tapered slightly, as this takes some of the weight of the burden of the coke and the partly melted iron. Of course, if the lining narrows at the melting zone, it is equivalent to using a cupola of a reduced size, whilst the greater liability of very irregular shaped linings to cause hanging is a disadvantage. Yet I think this has the effect of producing a sectional and radial distribution of the blast, which counts for economy.

With regard to the air supply, this depends on the forms, size, and disposition of the tuyeres, pressure, and distribution of the blast. Small tuyeres mean slow melting and dull metal. The tendency of modern practice is to enlarge the tuyeres; but there is no hard-and-fast rule. Different cupolas are working under different conditions with different blowers and different material, and the tuyere which suits one cupola does not suit another. The actual tuyere area should be arrived at by experience. But as a guide the writer recommends that the tuyere area be about 1-5th sectional area of the cupola, taken at the melting zone, and three times the area of the blower outlet. The diameter of the blast pipe should always be greater than the blower outlet, according to the length of the pipe in use. For instance, if the diameter of the blower outlet is 12 in. and the length of the pipe is 30ft., the diameter of the blast pipe should be 13 in.; if 60 ft., 14 in.; if 90 ft., 15 in., and so on. The shape of the tuyeres should be such that there is no friction or obstruction of the blast passing through them, and also no throttling of the blast, which wastes pressure. The blast pressure should only be sufficient to enable the air to reach the centre of the cupola. If the tuyere area is too big and the blast pressure is let down, this will be responsible for many failings, because the blast would not get to the material, and if the pressure is kept up, too much fuel will be burnt and the metal will come down too quickly, if sufficient fuel is put in. If too little fuel is put in the metal will come down impoverished. It is better to have sufficient tuyere area, because the area can be made less, though it is difficult in

* Read before the Lancashire Branch of the British Foundrymen's Association, April 5, 1919.

many cases to increase it where it has proved too small.

The old method of using pipes entering straight into the cupola, one on each side, making only two tuyeres, and these opposite each other, though not the worst method, failed to give good distribution of the air, and the disposing of a piece of metal lodging in front of the tuyere, forming an obstruction, is a serious matter. If this cannot be got rid of by poking, it means closing the tuyere until the obstruction has melted, and it is no easy matter to blow the air in it one opening. From the point of view of distribution, still retaining two tuyeres, to place them so that they do not enter opposite each other is a slight improvement. Some have tried running tuyeres into the cupola slanting, but this had the tendency to drive the air round the sides. The air belt is a great advantage, and allows more uniform distribution of the air and more tuyere openings.

Associated with tuyeres is the risk of " making up "; a lump of coke will burn and develop heat, but not so a lump of iron; with cold air blowing on it, instead of melting, it gets chilled. Many foundrymen say that the charge of iron should be placed round the outside of the cupola, but with this statement I do not agree, because the outcome of it is trouble in the tuyers getting " made up." The remedy is to close the tuyere until the iron has been removed by melting. I am not a great advocate of poking with a bar unless absolutely essential.

There is a great deal of misconception about the upper rows of tuyeres. If enough air can be admitted and a sufficient pressure got with one row, it is most advisable to work with one row, and the argument in favour of upper rows would fall flat. It is claimed that the upper rows help to burn the gases, but the fact of these tuyeres burning CO_2 is of no consequence; the thing that counts is the top rows of tuyeres are burning coke and the melting zone is being lifted higher up the cupola. A second row is unnecessary unless sufficient air cannot be got with one row. It is very significant that the manufacturers of cupolas with more than one row of tuyeres make special mention that doors are provided so that the upper rows may be closed if necessary. A third row of tuyeres further increases the difficulty. If it is found necessary to use a second row, the direction of the upper row should be downwards towards the melting zone. The tuyeres should be kept as near to the bed as possible, the nearer the better, as the metal loses heat standing on the bottom. So if hot metal is wanted, it is advisable to keep them low. In a paper by Mr. Mason a minimum height of 24 in. and a maximum height of 30 in. from the hearth to bottom of the tuyere were stated.

The height between the hearth and the sill of the charging door should be about 3§ times the diameter of the hearth for cupolas up to 42 in., and three times over this diameter. The object of controlling the height of the charging door is to completely utilise all the heat from the hot gases, as they ascend the cupola, by allowing them to pass through a sufficient amount of material and become reasonably cooled. From the charging door to the top of the stack should never be contracted, as shown in Fig. 1, to a smaller diameter, but should rather be of a larger diameter inside, as this allows the gases a clear passage without inconveniencing the men who are charging.

The slag hole should not be more than 10 in., or less than 5 ins., above the hearth; nor should it be less than 12 ins. below the tuyeres (bottom row if multiple tuyeres).

The blast main conveying the air need not be of thicker metal than 3-16 in. if made of wrought iron, and it is better placed above the ground than under the floor, as any obstructions are more readily got at. It need not enter the air belt at more than one point, and should be slightly larger than the outlet of the blower. As previously mentioned, air belts are a decided advantage, and they should be of larger area than the area of the tuyere openings. This gives an opportunity for the air to enter the tuyeres equally.

When starting the day's blow the cupola is lighted up in the usual way, and the bed charge then put on. As all cupolas do not behave alike, the height of the bed charge should be ascertained by experiment, but in many foundries it is the practice to charge 12 to 16 ins. above the tuyeres. The quantity of coke should be measured and varied according to the time and condition of the iron coming down. A few days' careful watching and measuring will give the most suitable height and ensure economical working. Apart from the saving in coke, if more coke than is necessary is put on, it will take the metal longer to come down, besides being longer in contact with the coke, which is very detrimental, because a portion of the sulphur in the coke combines with the iron, and renders it hard and sluggish. As the bed charge is from ten to twenty times as large as any of the succeeding charges of coke, the injurious effect should easily be seen.

It has often been suggested that the hardness of the first tap is due to the specific state of the carbon, and is caused by the molten metal falling on a cold hearth. I entirely disagree with this theory. I admit that the hardness is due to the specific state of the carbon, but this is brought about by the absorption of sulphur converting the carbon to combined carbon, and not thrugh the metal falling on a cold hearth. Dull, sluggish iron may result from a cold hearth, but not hard, brittle iron, which on analysis reveals a high sulphur content.

Proceeding with the first charge of iron, the weight should be determined by the area of the cupola. It is very common to see furnaces overburdened, both in iron and in coke, which does not induce regular melting and uniform results. The following I consider to be reasonable charges for different cupolas :—

Diameter in inches.	Charge in cwts.
24	6
36	12
48	20
60	25
72	30

Following the first charge of iron, coke is charged, and the question then arises, how much coke is required per ton of iron? Before this point can be settled, there are many points that must not be overlooked, such as composition and cleanliness of the pig-iron and scrap, quality of the coke and the class of work for which the iron is required, whether medium, heavy, or light. To mention two extreme instances, if the analysis of the iron shows a high

phosphorus content, say 1.5 to 1.75 per cent., a less quantity of coke per ton of iron can be used than with an iron containing 0.5 per cent. or even less. With a high phosphorus content, the fluidity is increased, and the melting-point is decreased. With such phosphoric irons other conditions being favourable, 1½ to 1¾ cwts. of good coke per ton of metal will give good results.

If, on the other hand, an iron is used that is low in impurities (say total carbon 3 per cent., silicon under 1 per cent., sulphur .04 per cent., phosphorus under 0.5 per cent.) it would have a higher melting point and a narrower range of fluidity, owing to the absence of the impurities which assist in retaining the fluidity. Such an iron, to give a clean, fluid, hot iron, would require 2 to 2½ cwts. of coke per ton of iron. In neither of these instances is the bed charge included, because I think it incorrect to distribute the bed charge over the whole melt for comparative purposes, as it would be the same for a 20-ton as for a 60-ton blow.

The quality and composition of the coke should be within definite limits, as quality must be considered in relation to quantity used. A low-priced coke may prove dear, if it is cheap because it is poor; and the evils of poor coke are many. Such a coke works against you in keeping a clean cupola; it also produces dirty and sluggish iron, and the worst of all, as poor quality cokes are frequently high in sulphur, and the iron has a great affinity for sulphur, hard and brittle castings are produced. Furthermore, there is also a great deal more ash, and this necessitates the addition of more flux to get rid of the ask. A good foundry coke should be high in fixed carbon, fairly hard, with a small cell structure. The following are the working limits, and the analysis of a well-known foundry coke respectively :—

		Per cent.	Per cent.
Fixed carbon	not less than	88.5	85.33
Sulphur	under... ...	1.5	1.04
Volatile matter	not more than	1.0	.78
Ash	under... ...	10.0	10.30
Moisture	about... ...	2.0	2.55

It must be remembered that a low coke consumption is not the only thing to be aimed at. Hot and rapid melting are of equal importance, and unless the metal is at the proper temperature good castings cannot be made. For this reason the figures obtained on heavy work are more favourable than that obtained on lighter work, where hotter iron is required, using the same materials. Thus, on the same cupola for heavy work the ratio worked out at 1—10 approx., while the ratio for light work gave 1—6, and for medium work 1—7.5 approx.

In very small castings it may be as low as 1—5. The " melting ratio " is a rather loosely applied term. It can be either inclusive of bed charge or exclusive of bed charge, and can also be based on the total metal recvered, fr instance, metal charged minus the melting loss, or the total metal charged. But for comparative purposes I would exclude the bed charge and compare with the metal charged. But where returns have to be made in works practice, the actual fuel expended for iron produced is required, and it becomes essential to count all coke charged less the amount recovered at the end of the blow, and compare against the actual metal tapped out of the cupola. The following is a typical charge :—

	Cwts.
Total coke charged in cupola ...	19.5
Less coke recovered...	.8
Actual coke consumption... ...	18.7
Iron charged :—	
Brand A	34.0
,, B	32.0
,, C	19.0
,, D	16.0
Scrap and gates	110.0
Total metal charged	211.0
Less melting loss, 5 per cent. ...	11.0
Metal recovered...	200.0
Ratio	$\frac{18.7}{200} = \frac{1}{1099}$

Following the coke comes the flux, and this is charged either in the form of limestone, which is calcium carbonate, or carbonate of lime, or fluorspar, which is calcium fluoride, both of which have been found suitable for the cupola. The flux generally used is limestone, but other substances can be used, such as shells or marble chippings. The limestone should always be as pure as possible and free from sulphate of lime. The amount to be used varies according to the quality of the coke and the amount of sand adhering to the pig and scrap, the effect of which will be shown later. Each part of sand would require three to five times its weight of limestone, but as it is assisted by the ash of the coke, which contains a little lime, and by the oxide of iron from the pig and scrap, less is required. A slight excess will not make the slag less fusible, and it is better to err on this side. With clean pig and scrap and using good coke as low as 28 lbs. per ton of iron charged can be used; but the amount will vary according to the amount of sand and dirt charged into the cupola. The following is a typical analysis of a limestone :—

Ca CO_3, 92.63; Si O_2, 3.82; Fe_2 O_3 and Ae_2 O_3, 1.173; MgO, 2.376. Reactions occurring in the cupola.

In the cupola very little reduction goes on compared with the blast furnace, which is smelting ores, and we can safely take it that cast iron is porous, otherwise it would not absorb heat. The air passes through the tuyeres, and comes in contact with the burning coke and increases the rate of combustion, making it an incandescent mass, which attains a temperature which is more than sufficient to melt cast iron, about 1,600 to 1,700 deg. C. The cupola has been previously referred to as " a small blast furnace," yet while this is true to some extent, it is quite distinct from the blast furnace. While the object of the cupola is to melt or liquefy the metal, the blast furnace reduces the iron from its combination with other elements, as in ore, to the metallic state. In the blast furnace a temperature is reached between 1,800 and 2,000 deg. C. Such a temperature in a cupola is unnecessary, as practically no reduction takes place, the only oxidation is that required for the complete combustion of the coke and the formation of a fluid slag. In fact, if such a high temperature were reached in the cupola, probably all the iron would be burned.

The requisite air is forced through the tuyeres with the formation of CO_2 and CO_3. As the rate and completeness of combustion depend on the air

supply, an insufficient volume will convert the carbon of the coke to CO instead of CO_2. The CO_2 is largely produced when an adequate supply is provided. Its importance will readily be seen when it is considered that carbon burning to CO_2 produces 8,080 calories, or 14,544 B.T.U., and carbon burning to CO produces 2,473 calories, or 4,451 B.T.U. The CO is combustible, and if sufficient air is supplied it can be converted to CO_2, this being the object of multiple tuyeres. Under perfect conditions the gases should be cooled at the charging door. If the gases are blazing at the charging door, or if when they strike a projection they show a blue flame, they are escaping at a temperature of 282 deg. C., and perfect conditions are not being obtained.

In addition to melting the iron, heat is also required by the flux to bring about the various reactions. Heat is also lost by radiation, by incomplete combustion of the fuel, and by passing up the stack, so that between theoretical values and actual practice there is a big margin which must be allowed for; but approximately 1 lb. of coke completely burnt requires 150 cub. ft. of air, and should melt 10 lbs. of iron. The amount of carbon required to melt 1 ton of iron is 77.85 lbs., and the amount of carbon to melt 1 lb. of iron is .034 lb.

There is charged in the cupola a certain amount of sand and other foreign matter, which is associated with the pig and scrap mainly, and also with the coke. This material is "acid" in character, and requires a material "basic" in character to form a fusible slag in the fusion zone. The material to be fluxed is chiefly acid, and the fluxes used are limestone, or fluorspar, which are basic.

An acid is the oxide of a non-metal, and with few exceptions a base is the oxide of a metal. The acids and bases, having a strong affinity for each other, depending on the compound, they combine to form definite compounds. When the limestone reaches the hot zone a series of cracking noises are heard, due to the evolution of CO_2 separating from the limestone, resulting in lime which goes down with the charge, until a temperature of 980 deg. C. is reached, when it combines with silica and other foreign matter to form a slag.

The following are the reactions that takes place:—

(1) $Ca\ CO_3 = Ca\ O + CO_2$.

Limestone is reduced to lime and CO_2.

(2) $Ca\ O + Si\ O_2 = Ca\ O\ Si\ O_2$, or $Ca\ Si\ O_3$.

This is actually the first combination that takes place on account of the lime being a strong basic substance and having a great affinity for silica.

(3) $Fe\ O + Si\ O_2 = Fe\ Si\ O_3$, or $Fe\ O\ Si\ O_2$.

This combination takes place either through not providing sufficient lime to combine with the silica or through having an excessive oxidation of iron to oxide of iron, owing to the metal being too much exposed to the action of the blast.

(Final) $Ca\ O + Fe\ S = Ca\ S + Fe\ O$.

Should there be an excess of lime still left uncombined with the silica the lime takes up the sulphur, which owes its presence to the pig-iron and to the coke. As already mentioned, slag is produced from the oxidation of silicon, manganese and iron of the metal, from the sand adhering to the scrap and pig, from the coke, and, further, from the fluxing materials. Pure calcium carbonate contains 56 per cent. lime and 44 per cent. CO_2. Fluorspar, often termed "Bohemian flux," is regarded as a more effective flux than limestone, and it is claimed it also reduces the sulphur, or at any rate prevents the absorption of sulphur during melting, thereby improving the quality of the metal. It acts on silicates in two ways:—(1) By combining with the silicates to form a fusible compound. (2) By decomposing the silicates and forming gaseous silicon fluoride ($Si\ F_4$). Both limestone and fluorspar are lime-producing materials, but, weight for weight, fluorspar contains 10 per cent. more lime-producing calcium than limestone, and while 44 per cent. of limestone is volatilised as CO_2, which passes up the stack, the whole of the fluorspar is utilised owing to it not being decomposed until the melting zone is reached, where it produced a thin fluid slag. The form in which the calcium is released is not as lime, as in the case of limestone, but as calcium according to the equation:—

$Ca\ F_2 = Ca + F_2$. $2\ Ca + O_2 = 2\ Ca\ O$.

$2\ F_2 + Si = Si\ F_4$.

It must not be forgotten that an excess of flux is all right, but a large excess will go for the cupola lining.

With cupolas running daily on one class of material, the fluidity, colour and general appearance of the slag will give some indication of the condition of the melting.

The effect of charging sand and other foreign matter with the materials may be mentioned. As an example:—To find the approximate amount of limestone under the following conditions:—Metal charge, ½ ton of pig iron, ½ ton scrap (runners and bad castings). Coke charge, 2 cwts. per ton of metal melted. Considering the substances from which slag is produced, we have the following:—Sand adhering to pig iron=30 lbs. per ton; sand adhering to scrap=40 lbs. per ton; or 1 ton of half pig and half scrap $= \frac{30+40}{2} = \frac{2}{2} = 35$ lbs. Amount of ash in coke=10.3 per cent.; or per charge of 2 cwts., take 10.3 per cent. $= 2.2 \times 10.3 = 22.6$ lbs. Amount of silica in 22.6 lbs.=say 15 lbs. There is also oxidation of silicon, manganese and iron, which amounts in the case of silicon to about 0.2

Typical Analyses of Cupola Slags.

Silica (SiO_2).	Alumina (Al_2O_3).	Ferrous oxide (Fe_2O_3).	Manganese oxide (Mr.O)	Lime (CaO).	Magnesia (Mg.O,.	Sulphur (S).	Calcium (Ca).
Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
54.1	11 5	15.3	3 5)	9 75	0.60	0.17	0.23
55.2	11.6	9.9	1.16	15 52	0.49	0.22	0.28
59.4	10.3	2) 9	4.00	9 80	0.74	0.18	0.22
46.7	9 6	7.3	2.79	31.60	0.1)	0.40	0.50

per cent., or, say, 5 lbs., and the manganese and iron another 5 per cent.; so we obtain:—

Slag-producing substance.

	lbs.
Adhering sand	35
Ash in coke	15
Through oxidation	10
Total	60 lbs.

This 60 lbs. is slag-producing material, and is almost entirely silica, or of similar affinity to limestone, and we derive the following chemical formula:—

$$Si\ O_2 + Ca\ CO_3 = (Ca\ Si\ O_3) + CO_2.$$
$$60 + 100 = 116 + 44.$$

60 parts of silica require 100 parts of $Ca\ CO_3$, or 1 part of silica requires $\frac{100}{60} = 1.66$ parts $Ca\ CO_3$; or 60 lbs. of $Si\ O_2$ require $60 \times 1.66 = 100$ lbs. (approx.) of $Ca\ CO_3$.

Should lime be used in place of limestone, we obtain the following:—

$$Si\ O_2 + Ca\ O = Ca\ Si\ O_3, \text{ or}$$
$$60 + 56 = 116.$$

60 parts of silica require 56 parts of lime, 1 part silica requires $\frac{56}{60} = 0.9$ parts of lime, or 60 lbs. of silica = 54 lbs. of lime.

For the purpose of cupola calculations the limestone may be taken as pure calcium carbonate.

Extensions to Clarence Ironworks.

During the past few years much has been done to bring the Clarence Ironworks of Messrs. Bell Brothers, Limited, Port Clarence, Middlesbrough, well into line with modern practice, particularly in regard to the lay out of the furnace plant, with a view to economising labour. The two furnaces which were pulled down are being replaced by a furnace with an automatic charger, which has been designed and is being erected by Messrs. Head Wrightson & Company, Limited. The furnace is designed for a make of 1,500 tons of Cleveland iron per week. Its gas will be thoroughly cleaned, first by passing through an elaborate system of dust catchers, and, finally, by treatment in an electrical gas-cleaning plant by the Lodge Fume Company. The gas will be fired under boilers to raise steam for a Fraser & Chalmers high-pressure turbo-blower; also for Cowper stoves for heating the blast. The new furnace, the shell of which is now completed, is known as the "C" furnace in a group of four, which with the kilns and storage bunkers form three parallel lines at right-angles to the coke ovens from which the furnaces draw their supplies. The coke track is being extended so that the loaded hoppers will be delivered on the bogies direct to the feed of the automatic charger of the new furnace. A gantry is being erected with the kilns on the one side and the storage bunkers on the other, the span being approximately 28 ft., which will be travelled by a 10-ton Herbert-Morris crane, and this will deliver the charges of coke to the other furnace hoists. The discharge shutes from the kilns have been re-disposed so as to bring three into line on each side of the delivery side, and the kilns will be served by trolley tracks. A gantry 850 ft. in length by 120 ft. span has been erected over the pig beds on the new side, and this carries two Herbert-Morris 5-ton electric-magnet cranes, which serve to load the Cleveland iron direct into the railway wagons and to deliver the hematite—the product of one of the furnaces—to a Lowca breaker.

A shop has been erected for the production of special alloy steels, for which purpose a Héroult 7-ton electric furnace, built by Messrs. Thwaites Brothers, Limited, Bradford, has been installed, the furnace and casting floor being served by a Herbert-Morris 16-ton crane. The 20-in. electrodes are automatically and electrically controlled, and the ingots are cast in groups of four, a system of gas-heating being provided for the moulds. The furnace has uniformly produced an average of 120 tons of special steel per week, the life of the roof being three weeks.

A new fitting shop has just been finished, which it is interesting to note was designed and built by the works staff. The shop is covered by a main and two side bays 200 ft. in length, with a span for the main bay of 38 ft., the runways carrying a 10-ton Herbert-Morris crane. The fitting shop has been laid down as a self-contained works. At one end of the building there is a works mess-room provided with cooking appliances, and also a locker room.

For the most part the tools have been transferred from the old fitting shop. Some useful additions have been made to them in the form of a morticing machine for cutting keyways, a millwork wheel-cutting machine, and a George Richards universal surfacing and boring machine of the Pearn-Richards type. At the time of our representative's visit this machine was engaged in boring a hydraulic cylinder for a steel-works hoist, the casting weighing 5½ tons, which is about the largest casting made in the Clarence Works foundry. The machines are driven in groups by four 20-h.p. Westinghouse motors. The method of carrying the machine countershafts is ingenious and somewhat unusual. Secured to the columns on either side of the bay are a couple of girders, which are carried below the main driving shaft and extend, as does the shaft, for the full length of the shop. The countershaft hangers are carried in short lengths of channels, which can be locked in any desired position on the girder track. This, of course, eliminates the necessity of making bolt-holes, and at the same time simplifies the installation of a new machine or the transference of a machine from one point to another. At the far end of the shop is a locomotive pit for repairs, all such repairs being executed at the works.

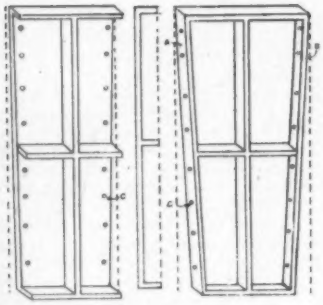
Another ingenious tool, which occupies a separate shop, was evolved and built in its entirety by the staff from odds and ends of material available on the works. It is a vertical boring head for turning up the furnace bells. This machine carries a 12-ft. dia. table, the periphery of which is built up in the form of a gear into which the driving pinion meshes, whilst on a bench immediately at the side of the table is a universal drilling machine for drilling holes, when desired, whilst the work is on the table. Although an examination reveals a very ingenious combination of unusual parts, the complete machine is by no means crude; it turns out remarkably good work, and, of course, in a tithe of the time of the usual hand-chipping process. It is driven by the same motor as the pug-mill.

At the present time the management of the Clarence Works are engaged upon two very important innovations:—(1) The erection of a sintering plant, which will be capable of dealing with 600 tons of ore in the 24 hours. It is anticipated that this plant will be in operation by the close of the year, and at the moment the company have on hand a stock of 19,000 tons of ore for treatment. (2) At the same time, a plant is being put down for the manufacture of slag bricks, the company having already determined by practical experiment the possibility of making a very serviceable brick from the slag with a small percentage of lime added The plant, therefore, now being installed (by Herbert Alexander & Company, Limited) is designed for a considerable output.

Moulding Ingot Moulds.

By A. B. Smith.

The following is a description of tackle used, and the method of making ingot moulds. The work is of a repetition nature, and is carried out by unskilled labourers. The moulds are made in various sizes, and the one described is the most popular size, averaging about 6 ft. in height and 2 ft. at the base, tapering to a top of about 20 ins. square, having rounded corners, and about 3 to 4 ins. thick. Two staples are cast in for lifting purposes, as seen at Fig. 5.



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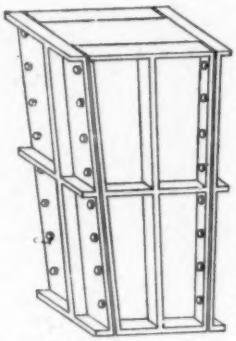

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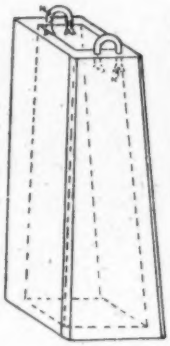

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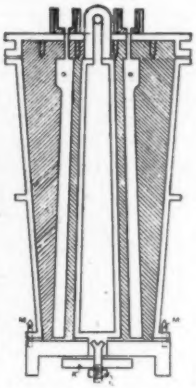
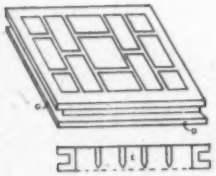


6.

The moulds are cast lengthwise as in Fig. C, and made in pits, the tops of the job being about a foot above the ground floor.

Boxes.—These are made on the tank-plate system and cast open-sand, tapering from end to end as seen in the first four sketches, the two inside plates (Fig. 3) being flanged as at A and B. The outside plate (Fig. 1) is ribbed only and cores are cast in corresponding to C (Figs. 1 and 2), for subsequent bolting together as in Fig. 4, C, the four plates forming a tapered box, Fig. 4. The top box part is cast with a double flange for added strength, as in Fig. 7, section E, and the size is exactly the same as in Fig. 4, the job being completely flat. No pins are required, and the boxes are lifted by cam hooks under the flanges. No trunnions are required.



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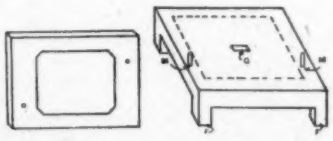


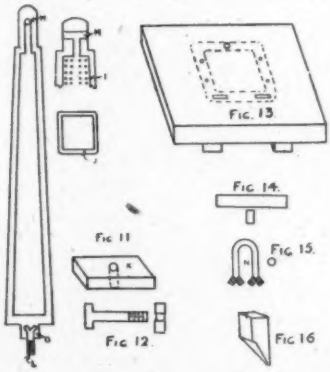
8. 9.

The bottom part is a thick plate exactly the same size as the base of the centre box, Fig. 9, having four feet cast on as at F, and a slot in the centre, G, corresponding with the projection on the core bar G, Fig. 10.

Core Bar.—The centre core (Fig. 10) is of the same shape as the pattern and of a size to allow about two inches of sand between the pattern and the core iron from top to bottom; the inside core is as Fig. 10, finishing with a round tee core at the head as at H, to allow of free passage of air, this being vented by means of cored holes (Fig. 10, I). The section is seen at J. Fig. 11 is the packing piece (Fig. 6, K), a screw bolt L being cast in the core bar at base slot G.

Moulding.—First the core bar is fastened and well screwed up by the bolt L passing through the slot G in the base plate (Figs. 9 and 6). It can then be picked up and lowered into the pit in the following manner.

Fig. 12 is a bolt or pin which is passed through the hole H, Fig. 10. A short chain with two large links is then slipped over the head and nut, when the core bar and plate can be slung into any position. When this is levelled on the pit bottom it is then given a good coat of charcoal blacking, this being considered a better adherent than clay-wash. A template plate, Fig. 8, is then passed over the core bar and lowered over the pins M, M, on to the base plate, Fig. 9.



10. 11-16.

The centre of the template acts as a guide for the pattern. The pattern is next lowered on and

slipping through the template rests on the bottom plate.

The box, Fig. 4, is next placed in position as at Fig. 6, and ramming is done, special long rammers being used, generally ramming the core and mould alternately until within a short distance of the top, when, if necessary, strengthening pieces may be added to form an extra thickness under the wrought iron loops, Figs. 5 and 14, N and O, Figs. 16 and 6; but this is not always required, there being a good thickness of metal.

The ramming having been done to the top, the joint is made by levelling off the sand and damping with a wet brush. The box may now be removed by a pair of comb hooks, placing them centrally on the top flanges of the box.

When the mould is removed, leaving the pattern behind, it is placed on four pedestals, so as to enable a person to get inside to finish it over and black it previous to stoving. The pattern is next removed by a pair of hook chains and the loops at the top, a slight rapping being given round the sides. This done, the template is taken away and the core blacked, and also the bottom plate is given a thick coat of blacking.

Top Parts.—These tops are rammed off a board as Fig. 13; the dotted lines indicate the position of the casting. Holes are cut in for the gates and risers and also for the staples, and the centre of the box is left open for the centre of the core bar to pass through.

When the ramming is completed the board and box are cramped together and turned over on to four hicks or a bed and the board removed; the mould is then given a good coating of blacking, omitting, of course, the staples, the ends of which are given a coating of red lead; it is then stoved and dried.

Casting.—Assuming the moulds are thoroughly dry, the core bar and bottom plate are picked up and placed in the pit. A thin layer of wet loam is put around the outside edge, and the centre box is lowered into position, the loam ensuring a good bedding all round; the top box is then lowered over the corebar head and on to the mould, care being taken to ensure the bar being central in the box.

When this has been done loose sand is rammed in between the sides of the corebar and the centre of the box; the runner is then made up and the riser, the top and bottom boxes being cramped to the centre box by means of the flanges, no weights being required. A short period is allowed to elapse after casting to allow of cooling or setting and the job is dismantled while hot, as this method saves a great deal of time and labour in stripping.

EXODUS OF ALIENS FROM AMERICA. — "The Iron Trade Review" in a recent note dated from Washington states that, according to the Inspection Service of the Department of Labour, many aliens are planning to return to their mother countries within a short time. Investigations conducted by the Service revealed the fact that the greatest number of foreigners intending to return are in the iron and steel industry. Whether the exodus will seriously affect the industries of the country, the Labour Department officials cannot say. It is believed, however, that the removal of a large proportion of foreign labour will either level the supply and demand there or that there will be a considerable shortage. Officials refuse to commit themselves to estimates of the migration.

Power from Tidal Waters.

Engineers will be interested in a scheme which has been evolved by Mr. J. Smith, of J. Smith & Company, engineers, Glasgow, whereby the harnessing of tidal waters for generating electricity is claimed to be brought within grasp of actual fulfilment. As a result of correspondence which has passed between Mr. Smith and the Board of Trade in connection with his scheme, the Department has shown itself anxious to put the idea of the patentee to a searching test. To this end the Water Power Committee of the Board of Trade have asked for particulars as to sites, plant and first cost, and the patentee has furnished them with the following details of his scheme :—

The River Severn at Portishead supplies 4,773,730 h.p., being 74½ miles long by one mile wide by 17 ft. deep, displacing 187,921,251 cub. ft. per minute at 17 ft. head of water for three hours. The Dee, at Point of Air, the Menai Straits, and the Mersey, above Liverpool Docks, show a total of 5,651,984 h.p., being 122 miles long by one mile wide by 14 ft. deep, displacing 270,780,050 cub. ft. per minute, at 14 ft. head of water for three hours, and providing a total of 10,425,714 h.p. The average half h.p. is 5,212,857, the Severn borrowing from the Mersey. The total h.p. obtainable is 5,500,000 borrowing from the Mersey, and using part surplus water. The total surface mileage is 196½ miles by one mile wide for use in six hours, and the total approximate cost is £85,500,000, including cable for an area of 170 miles. The total average cost per h.p. is £16 17s. 4d., and current could be distributed at 1/30th of a penny per Board of Trade Unit. This provides for depreciation, working expenses, and 5 per cent. interest on capital. By this scheme, it is claimed, power could be distributed at about 1/50th of the present cost.

Two or more rivers are required to work this scheme to obtain the constant head of water needful. They work alternately, thus keeping up a constant supply, and overcoming the difficulty of high and low water. The rise and fall of the Severn is 34 ft., and only half of this—17 ft.—is used, the other half making the head which is kept during the whole time the turbines are working. The amount of water constantly passing over this fall for three hours is 187,921,251 cub. ft. per minute. The area of water used by this head is equal to 74.5 miles in length by one mile broad by 17 ft. deep. In the case of the Dee, which has 28 ft. rise and fall, a constant head of 14 ft. is ensured, and at this fall there is 123,099,300 cub. ft. per minute. The area of water used by this head during its three hours run averages 15 miles long by 4 miles broad by 14 ft. deep.

As regards the Menai Straits, a constant head of water, 14 ft., is available again, and displacing 47,687,733 cub. ft. per minute. As for the Mersey scheme, where the tide is 26 ft., a constant head of 13 ft. of water is supplied, and here the cub. ft. of water displaced is 99,977,710, with an average mileage of 40 miles long by one mile broad by 13 ft. deep. This provides from the four rivers mentioned a constant h.p. of 5,212,779 per minute, and by using all the available power a total of 5,500,000 h.p. can be obtained.

The average first cost per h.p. (pre-war price) in Mr. Smith's scheme is £9 8s., as compared with the £38 per h.p. for the nine waterways lately suggested to the Water Power Committee. After the initial outlay the only charge so far as expenditure is concerned will be wages, interest on capital, and ordinary wear and tear of plant. To meet this the power could be distributed at 1/30th of a penny per Board of Trade Unit.

Details as to the mechanical operation of the scheme are given in an explanatory guide prepared by Mr. Smith. The estimate is based on a 57-in. "Achilles" turbine. It also includes locks and basins for the Severn and Mersey for shipping.

Graphitisation in Iron-Carbon Alloys.

By Kunichi Tawara and Genshichi Asahara (Tokyo University).

(*Abstract.*)

About one kilogramme of charcoal-iron was charged in a Morgan's clay crucible together with a certain quantity of hard charcoal (C = 87 per cent.) and heated in a Deville's furnace with blast until it melted, no charcoal remaining on the surface of the melt. The molten alloy was cast in a flat rectangular metallic mould, white pig-iron containing nothing but carbon and iron being obtained. About 20 kgs. of the alloy were prepared in separate casts, their carbon content varying between 2.95 per cent. (minimum) and 3.92 per cent. (maximum). One of the casts prepared in this manner, and taken at random, gave on analysis 0.10 per cent. of silicon, an amount which can safely be disregarded in considering the results.

In preparing the alloys the temperature which the molten metal reached during the heating (the "highest temperature") and the temperature at which the metal was cast (the "casting temperature") were measured respectively. Measurements by the Féry patent pyrometer having proved difficult, a thermo-couple was used, protected by a silica tube.

The highest temperature was measured by dipping the thermo-element into the molten metal, which was then allowed to cool, the thermo-element remaining in position until the desired casting temperature was reached.

The moulds used in the experiments were, in most cases, of fireclay mixed with coarsely powdered crucible material, and were of the shape of an equilateral triangular prism, the side of the equilateral triangle being 1½ in. long. In all cases the mould had previously been heated in a concentric gas-jet crucible furnace up to a certain temperature before the molten metal was cast in it. The temperature was measured with a thermo-couple which was inserted into a hole in the mould. The ingot, after this treatment, was slowly cooled in the furnace or quenched in water. It was then examined microscopically and chemically. The arrangement adopted is sketched in Fig. 1. The average temperature throughout the experiment is cited as the "temperature of the mould" for the sake of convenience, where necessary.

Table I. shows the results of the experiments. All the samples were analysed for carbon and silicon, and in one case, chosen at random, the phosphorus, sulphur, copper, and manganese were also estimated. The result was as follows:—Phosphorus, 0.06 per cent.; sulphur, 0.09 per cent.; manganese, trace; copper, nil. No practical effect may be expected from these minute quantities. The experiments were so devised that only one factor differed in each case, namely, the six variables—with regard to graphitisation: (1) The chemical composition of the alloys; (2) the "highest temperature"; (3) the "casting temperature; (4) the "temperature of the mould"; (5) the "time"; and (6) the "mode of cooling" of the reguli. The effects on the microscopical constituents and structure due to each of those factors were as follows:—

Chemical Composition of the Alloys.—It depends largely, of course, upon the chemical composition, whether graphitisation occurs or not. The material used in the experiments containing practically nothing but iron and carbon, graphitisation, if present, is certainly not caused by such impurities, as silicon, etc. Indeed, the graphitisation in the experiments is almost entirely due to the slow cooling of the metal at or near its solidification point. Graphite is always to be seen in an ingot which has been slowly cooled, even when there is practically no silicon.

No. 5 and No. 6 underwent nearly the same heat treatments and differed only in carbon contents. The percentages of carbon in these two alloys were found to be 3.93 per cent. and 3.45 per cent. respectively. So far as the present results were concerned, there was no marked effect upon the structure by the change in carbon content within certain limits (0.5 per cent. fluctuation). In No. 7 graphite was present in very small quantity and in a certain limited space. The mass was very much like white iron.

It might be assumed from these examples that the quantity of graphite (under the same conditions) depended on the carbon content of the alloy, the quantity in No. 5 being considerably greater than in No. 7 even when compared with No. 6. This is explained by assuming that the excess carbon over 2 per cent. (which is the limit of saturation of primary austenite) crystallised out as graphite. On the other hand, the above conclusion might be expected from the equilibrium diagram of the FeC system. The carbon percentage of any alloy in the experiments is between 2 per cent. and 4 per cent., so that the constituents which appear at the time of solidification are primary austenite and graphite, and no other new constituent is introduced. Moreover, the increase in carbon content means, in the equilibrium diagram, the approach to the eutectic freezing point of primary austenite and graphite. Accordingly, more graphite should be produced out of the carbon which is in excess of the limit of saturation of austenite with carbon.

In No. 8 the highest temperature and the casting temperature are higher than in the other three cases, besides which the carbon is as low as 2.18 per cent. Graphite occurred in certain parts of the ingot. In this case it might be necessary to raise the casting

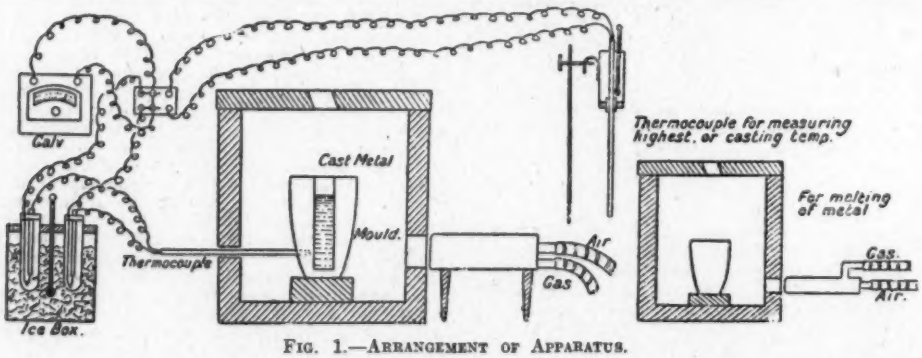


Fig. 1.—Arrangement of Apparatus.

temperature so as to make the case comparable with the others, because the percentage of carbon was smaller and the solidifying temperature was consequently higher. However, this is not strictly the case in No. 8, although it is evident that graphitisation can take place even when the content in carbon is as small as 2.18 per cent.

It may be assumed, therefore, that the amount of carbon in the alloys, when ranging from 2 per cent. to 4 per cent., is not a decisive factor in graphitisation. It causes no change in the species of microscopical constituents; but it influences the quantity of graphite produced.

2. *The Effect of the "Highest Temperature."*—

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Der.	Temp. of mould. Deg.	Time. Hours.	Mode of cooling
6	3.45	1336	1328	1100	1½	Slow
9	3.36	1436	1329	1100	1½	,,

On comparing No. 6 with No. 9, no perceptible difference could be found in their structures.

The result of the experiments shows that the "highest temperature," i.e., the maximum temperature which the molten metal has reached, has apparently no effect on graphitisation. In the experiments, therefore, no special precautions were taken respecting this factor, which varied within a certain range of temperatures.

3. *The Effect of the Casting Temperature.*—

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hours.	Mode of cooling.
6	3.45	1336	1328	1100	1½	Slow
18	3.34	1416	1399	1100	1½	,,

The temperature difference between the casting temperature and the temperature of the mould is the main factor which determines the solidifying velocity of a molten metal and the cooling velocity of the solidified mass, and it often controls the microscopical structure of alloys. The casting temperature in No. 18 was 71 deg. C. higher than in No. 6. The slight differences both in the chemical compositions and in the highest temperatures are quite negligible, as shown by the results.

4. *The Effect of the Temperature of the Mould.*—The temperature of a mould partly defines, as well as the casting temperature, the solidifying and cooling velocities of a molten metal. Rather higher temperatures, such as those chosen in the experiments, favour graphitisation, as they result in slow cooling.

(*a*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hr.	Mode of cooling.
21	3.60	1334	1318	1000	½	Water quenching.
22	3.58	1325	1317	1100	½	

In these cases ingot metals were rapidly quenched in water. In both cases graphite was seen in certain parts in the mass, showing that graphitisation could take place at 1,000 deg. C. as well as at 1,100 deg. C. These graphite flakes were not produced by the slow cooling down from these temperatures, as the mass was quenched at once.

(*b*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hrs.	Mode of cooling.
14	3.42	1393	1327	1100	1½	Water quenching
24	3.40	1339	1314	1125-1128	1½	

In No. 24 an effort was made to keep the temperature of the mould as near the eutectic temperature as possible. There is no graphite at all in No. 24, while there is plenty of it in No. 14. This was probably due to keeping the mould at 1.125 deg. to 1.128 deg. for 1½ hours, so that the eutectic, being unable to solidify at all, could not deposit graphite.

No. of experiment.	Highest temperature.	Casting temperature.	Temperature of the mould.	Time.	Mode of cooling.	Chemical composition.			Microscopic constituents.†
						Total carbon.	Graphite carbon.	Silicon.	
	Deg. C.	Deg. C.	Deg. C.	Hrs.		Per cent.	Per cent.	Per cent.	
1	1287	1237	1000	1½	Slow	3.20	*	0.02	G.C.P.(L.).
2	1274	1233	1100	1½	,,	—	*	0.05	G.C.P.
3	1315	1266	1100	1½	,,	—	*	—	G.C.P.
4	1301	1251	1100	1½	,,	3.08	*	0.03	G.C.P.
5	1355	1330	1100	1½	,,	3.93	2.18	0.05	G.C.P.
6	1336	1328	1100	1½	,,	3.45	1.53	0.04	G.C.P.
7	1333	1325	1100	1½	,,	2.48	*	0.02	G.C.P.(L.).
8	1409	1388	1100	1½	,,	2.18	*	0.05	G.C.P.
9	1436 (for each ½ hr.)	1329	1100	1½	,,	3.36	1.50	0.06	G.C.P.
10	1356	1323	1100	3	Very slow	3.25	1.64	0.01	G.C.P.
11	1402	1270	1100	0	Quenched in water	3.10	Nil	0.05	Ar.L.
13	1361	1328	1100	½	Slow	3.23	1.60	0.05	G.C.P.
14	1393	1327	1100	1½	Quenched in water.	3.42	1.26	0.02	M.G.
15	1346	1325	1100	—	Slow	3.65	2.14	0.03	G.C.P.
18	1416	1399	1100	1½	,,	3.34	1.73	0.03	G.C.P.
20	1357	1316	1000	8	Quenched in water	3.63	*	0.02	Ar.C.L.G.
21	1334	1318	1000	½	,,	3.60	*	0.01	Ar.C.L.G.
22	1325	1317	1100	½	,,	3.58	*	0.02	Ar.L.G.
23	1363	1322	900	7½	,,	3.42	Nil	0.03	Ar.L.
24	1339	1314	1122–1126	1½	,,	3.40	Nil	0.03	Ar.L.
27	1335	1323	50 (metre mould)	(Chilled	casting)	3.61	Nil	0.01	Ar.L

* Refers to partial graphitisation, *i.e.*, the presence of graphite in certain parts.
† G.=Graphite. C.=Cementite. P.=Pearlite. L.=Ledeburite. Ar.=Austenite (resolved). M=Martensite.

(*c*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hrs.	Mode of cooling.
20	3.63	1357	1316	1000	8	Water quenching.
23	3.42	1363	1322	900	7½	

In these cases the temperatures of the moulds were kept at 1,000 deg. C. and 900 dep. C. respectively for rather a long time. No. 23 did not contain even a trace of graphite, while No. 20 did. It is accordingly shown that graphitisation cannot take place at such a temperature as 900 deg. C., even when maintained for 7½ hours.

(*d*) In summarising the three cases, it is shown that the temperature of the mould has some effect on graphitisation. Graphite was not found in the case of 900 deg. C. A temperature of 1,100 deg. C. is the most favourable of the three.

5. *The Effect of the "Time" of Annealing.*—The

"time" of annealing means, in other words, the rate of cooling of a mass in the earlier stage.

(*a*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hrs.	Mode of cooling.
10	3.25	1356	1323	1100	3	Slow
6	3.45	1336	1328	1100	1½	,,
13	3.23	1361	1328	1100	½	,,
15	3.65	1346	1325	1100	0	,,

In these four cases no considerable microscopic change could be detected. Homogeneous graphitisation had taken place in every case. From this fact it may be concluded that when the temperature of the mould is 1,100 deg. C. there is no appreciable effect on graphitisation, whether the cooling of the metal begins directly after the casting or after three hours' annealing at the temperature.

(*b*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of Mould. Deg.	Time. Hrs.	Mode of cooling.
14	3.42	1393	1327	1100	1½	Water
22	3.58	1325	1317	1100	½	quenching

In No. 14 the microstructure was quite homogeneous throughout, and there was even distribution of graphite. On the other hand, graphitisation was not complete in No. 22, where graphite existed only in certain limited parts.

In these cases, therefore, the "time" seems to have exercised an effect apparently on graphitisation and gives a conclusion discordant with that of (*a*).

(*c*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time Hrs.	Mode of cooling.
20	3.63	1357	1316	1000	8	Water
21	3.60	1334	1318	1000	½	quenching.

In these examples graphite existed only in certain limited spots in both masses, and the structures were quite similar. So far as graphitisation is concerned, the "time" seems to have no effect on the completeness. It must be concluded from (*a*) and (*c*) that the "time" alone cannot exercise any appreciable effect on graphitisation, while (*b*) leads to an opposite conclusion. This discrepancy may be explained if we assume the minimum length of the "time" necessary for graphitisation to be, say 1½ hours, and also the favourable effect of the slow cooling.

6. *The Effect of the Mode of Cooling.*—

(*a*)

No. of experiment.	Per cent. carbon.	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time. Hrs.	Mode of cooling.
6	3.45	1336	1328	1100	1½	Slow
14	3.42	1393	1327	1100	1½	Water-quenching.

Graphite flakes were distributed throughout the mass in both cases, and their structural arrangement was similar microscopically. In No. 6 the ground mass consisted of pearlite and cementite (needle), while that in No. 14 was largely martensite. This shows that the difference of slow cooling and water quenching causes a change simply in the method of the decomposition of primary austenite, which constitutes the ground mass of the solidified metal, and is no serious factor in graphitisation. In other words, it shows that graphite crystals are not likely to be produced in the later stage of cooling.

(*b*)

No. of experiment.	Per cent. carbon	Highest temp. Deg.	Casting temp. Deg.	Temp. of mould. Deg.	Time Hrs.	Mode of cooling.
13	3.23	1361	1328	1100	½	Slow
22	3.58	1325	1317	1100	½	Water-quenching.

In No. 13 the distribution of graphite was homogeneous throughout, which was not the case in No. 22. It has been shown in No. 5 (*a*) that No. 13 and No. 6 are similar with regard to graphite. While No. 13 contains much graphite, it is open to question that No. 22 has a considerable amount of ledeburite, *i.e.*, a small quantity of graphite in certain limited parts.

On reviewing all the cases where the metal was quenched rapidly in water, we find that there prevails incomplete, limited graphitisation except in the case of No. 14. The quenching seems to prevent further graphitisation, *i.e.*, further decomposition of cementite at the later stage (admitting for the present the decomposition theory of graphitisation). Slow cooling, on the contrary, results in complete graphitisation. However, No. 14 shows that a sufficiently high temperature of the mould and a sufficient "time" will give complete graphitisation even when quenching takes place.

If we consider the results of No. 6 together with those of No. 5, it may be concluded that graphitisation must take place at a certain early stage of cooling of the metal, covering some length of time, and is, of course, favoured by higher temperature. The length of "time" must be at least 1½ hours (strictly speaking, longer than ½ hour) in order to get homogeneous graphitisation, and the quenching after a shorter "time" than this will therefore result in partial graphitisation. The slow cooling in the present experiment may have, in some cases, served to increase the "time" (though this is not definitely certain), thus helping graphitisation in those cases where the "time" did not amount to that required length.

It must be noted that the above remark holds good when the temperature of the mould is 1,100 deg. C., but is not true at 1,000 deg. and 900 deg. C. However, it is already known that the temperature 1,100 deg. is more favourable to graphitisation than the other.

If this be the case, it is quite inconsistent to assume that the slow cooling (especially when it follows after a shorter "time"), can favour graphitisation, notwithstanding that the temperature is steadily falling below those temperatures, such as 1,000 deg. and 900 deg. C.

The Authors' Theory as to Graphitisation.—Graphite crystals are always contained in an austenite mass (resolved) when they are directly produced by the slow cooling of an alloy. They are not necessarily to be ascribed to the decomposition of the eutectic cementite. The austenite areas, in which graphite crystals are present, are intimately associated with the austenite islets which are scattered in the eutectic. They may not differ much in chemical composition. As the austenite islets are, without doubt, the primary products from the molten alloy, the austenite beds are also supposed to be the product within a similar period, *i.e.*, they may appear side by side with graphite crystals at the eutectic point.

It is generally accepted that carbon exists as cementite in the molten iron-carbon alloys. It is probable that cementite, being a compound, may dissociate in the molten state into iron and carbon, even though the amount of the dissociation may be small. These free carbon atoms may serve as the *nuclei* for the graphitisation when the conditions are favourable.

When an iron-carbon alloy ($2 < \%\,C. < 4{\cdot}3$) is allowed to cool sufficiently slowly, the primary austenite crystallises out along the liquidus AB and the mother liquor reaches the eutectic composition B (Fig. 2). At this point, when the cooling is sufficiently slow to maintain the equilibrium, graphite will crystallise together with austenite, forming the eutectic, as there are a number of the *nuclei* already present. The deposition of the dissociated carbon from the molten system will bring about a further dissociation of the molten cementite, as a general rule, in order to re-establish equilibrium. This process is repeated and graphite crystals are developed. On the other hand, the residual molten alloy is diluted all the time by the ferrite, which is the contemporaneous product of the dissocia-

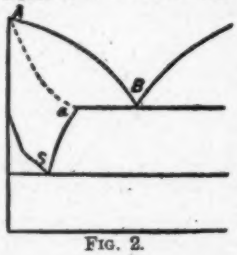


FIG. 2.

tion, and finally it will attain the composition A which corresponds with that of saturated austenite (2 per cent. carbon). We have thus a eutectic of graphite and saturated austenite in the final state, and the whole regulus consists only of graphite and austenite, the latter, of course, resolving into pearlite and needle-shaped cementite when cooled.

If the favourable conditions for the solidification of this eutectic of graphite and austenite cease—for example, if the rate of the cooling of the melt becomes greater over a certain range—that process will no longer take place, and cementite will crystallise out of the molten alloy. The separation of cementite at the point B does not represent a true equilibrium; it is a transitional and metastable condition. When the solidification of the alloy is not retarded sufficiently until the whole becomes solid, "mottled" iron will be obtained.

In the photomicrographs obtained by the authors, the portions with graphite crystals are regarded as consisting of the primary austenite and the eutectic (of austenite and graphite), the latter filling up the spaces between the "fir-tree form" of the primary austenite. The considerable difference in the dimensions of the constituents between the eutectic of graphite and austenite and the eutectic of cementite and austenite may be considered as the common phenomenon when the alloy is slowly cooled on one hand and quickly cooled on the other hand. In these cases it has been found that there is no ferrite around the graphite crystals, and the latter are intimately surrounded by the resolved austenites (needle cementite + pearlite). On examining the shape of the graphite crystals, it seems rather probable that they are the product of the molten mass, and not the product of the decomposition of cementite in the solid state.

James Watt Centenary.

August 25 of this year is the centenary of the close of James Watt's life. At a meeting of the engineers of Birmingham (the city of his adoption) it was decided that the occasion should not be allowed to pass without a celebration and the erection of a memorial, for which an international appeal is being made to all interested in the generation and use of motive power. A Provisional Committee has been elected and a scheme drafted. An inaugural public meeting was held in the Council House, Birmingham, on Thursday, at which the Lord Mayor presided. The provisional scheme, which was approved, is as follows:—Celebration:—(1) The Rector of Handsworth will hold a memorial service at Handsworth Parish Church, where James Watt, and also Boulton and Murdock, were buried, and where there is a James Watt Memorial Chapel, containing a monument to him by Chantry. (2) A garden party. (3) An exhibition of the Watt, Boulton and Murdock relics in the Council House, Birmingham. (4) A centenary dinner. (5) Addresses on the life and work of James Watt and the progress of engineering science during the hundred years by eminent men. (6) Visits to places of interest in the neighbourhood. Permanent Memorial:—It is felt that in view of Watt's original work, in both pure science and engineering, that the memorial to his memory should be of permanent value to both industry and science. With these objects in view it is proposed:—(1) To endow a professorship of engineering, to be known as the James Watt Chair, at the University of Birmingham, for the promotion of research in the fundamental principles underlying the production of power and the study of the conservation of the natural sources of energy. (2) To erect a James Watt Memorial Building, to serve as a museum for collecting together examples of the work of James Watt and his contemporaries, Boulton and Murdock, illustrating this interesting epoch in the history of engineering. The building would also serve as a meeting place and library for scientific and technical societies. (3) The publication of a memorial volume.

Canadian Mission in London.

The Canadian Mission, which has recently been established in London at 1, Regent Street, S.W.1, by the Dominion Government, was constituted by an Order of the Canadian Privy Council in November, 1918. Mr. Lloyd Harris, who was appointed Chairman of the Mission, is a Canadian business man who has a wide knowledge of the new industrial Canada, which is one of the products of the Great War. He rendered valuable service to the Dominion and to the Allied cause as head of the Canadian War Mission in Washington.

The serious tonnage position arising out of the war, coupled with the numerous restrictions put in force, both in the United Kingdom and in Canada, on import and export trade, tended to sever numerous old connections which had existed for generations between the Mother Country and the Dominion. It is one of the duties of the Mission to study the question at first-hand and to devise the means of re-establishing the traditional trade. Further, since in the great work of reconstruction and re-organisation to be undertaken in Europe during the next few years in order to repair the devastating effects of the war, raw materials, etc., will be necessary, and many articles required can be obtained from Canada, the Mission hopes by means of negotiations with the Governments of the countries concerned to make arrangements for the supply of such goods to the advantage of all interests involved. It is also considering how, by a system of credits, to assist the Governments in purchasing the materials.

The resettlement of Europe is largely dependent on sufficient supplies of food being available and distribution being properly organised. The food can only be obtained by imports from countries having margins for export, or by increased production in Europe itself. Canada has large supplies which she is willing to place at the disposal of Europe, and by reason of the fact that she has always specialised in the manufacture of agricultural machinery and implements she is in a position to come to the assistance of the nations of Europe in their endeavours to produce supplies within their own borders. In addition to foodstuffs of every description, Canada has available for export such goods as paper and paper manufactures, timber and wood manufactures, including wood pulp, motor cars and other vehicles, petrol launches, leather and leather manufactures, hides, aluminium, calcium carbide, asbestos, iron and steel manufactures, copper, gold quartz, silver, nickel, coal, clothing, furs, agricultural implements.

Canada has large markets to offer British manufacturers, for she is a large buyer; and she feels, too, that she can supply to this country many of the materials and manufactures which formerly were bought by Britain from the Central Powers.

Correspondence.

SIR,—May I take the privilege of asking through your valued paper, of which I am a reader, if any of your subscribers have proved the McLain's System to be all that it appears to be. We are only a small firm, but we feel that we should like to make something stronger than grey iron, and we think semi-steel would meet our purpose.—Yours, etc.,

K. E. W.

Fullwood Foundry.

The Fullwood Foundry Company, Limited, was incorporated in May, 1915, for the purpose of laying down a foundry and specialising in the production of ingot moulds, bottom plates and slag pots. A site was acquired at Mossend, Lanarkshire, about 10 miles from Glasgow and 30 miles from Edinburgh, the Glasgow to Edinburgh main line of the Caledonian Railway bounding one side of the property. The foundry is therefore in the heart of the Scottish steel-making industry, whilst it has excellent rail facilities to serve other centres.

The foundry building is covered by a single bay 285 ft. long by 60 ft. The floor, shown in Fig. 1,

View of Foundry.

is served by three electric cranes—a 50-ton with 10-ton auxiliary hoist, a 25-ton and a 10-ton, and in addition there are two electric wall cranes each of 1 ton capacity.

Stocking Ground showing Cupolas and Charging Platform.

There are two jolt ramming machines capable of ramming moulds up to 15 tons and 10 tons respectively; the tables of these machines are sunk so

as to bring the top of the mould box to the floor level to facilitate filling. The method of stripping is somewhat novel; the mould with the pattern in position is lifted from the ramming table to a plate above and at the side of the pit; bolts are passed through this plate into the bottom of the pattern, and the box is then lifted off by one of the cranes and carried to the pit, adjacent to the stoves, where any necessary patching is done.

The core department, at the same end of the foundry as the stoves, has also a jolt ramming machine. The six drying stoves are arranged in one battery and served by trolley tracks. They are coke-fired, the method of firing, however, being somewhat unique. Each stove has an independent firing chamber consisting of a rectangular cast-iron box, lined with firebrick, with a charging hole on the top, and connected through chequered brickwork openings to the stove. Placed at the rear of the firing chamber is an electrically-driven fan, which delivers the blast through a two-way pipe to above and below the fire level, both pipes being controlled by dampers. When lighting up, the bottom inlet only is used, and when the heat has developed, this damper is shut in so as only to admit sufficient blast to maintain a hot fire. The top damper is then opened and delivers its blast across the fire into the stove. The stoves are served by a chimney merely sufficiently high to carry off the gases. The loading platform for feeding the combustion chambers is at truck level, so that there is a minimum handling of fuel.

The foundry floor is provided with four casting pits which are conveniently placed to the three side by side cupolas, each of which is capable of melting down 14 tons of iron per hour. The charging platform, which is common to all three, is served by a 10-ton crane, the gantry of which extends completely across the stocking ground.

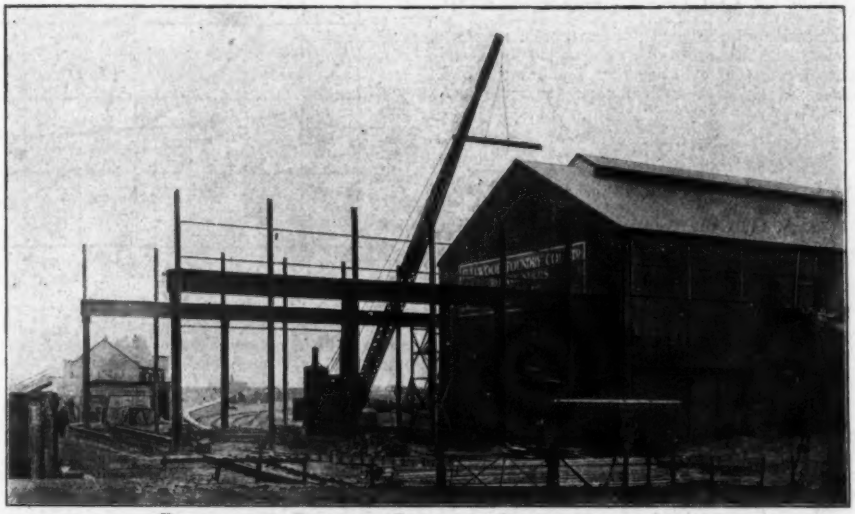
Blast for the cupolas is supplied by two fans housed in a dust-proof building. A lean-to building covers the patternmakers' and joiners' shops.

Electric power is taken from the Clyde Valley Electrical Power Company. The works control gear is on the separate unit system, and is housed in lean-to buildings, in a portion of which, fenced off, are two compressors which deliver to two receivers at 100 lbs., pressure and are each driven through belts from 40-h.p. motors.

Dressing in the meantime is being done in the open yard. In addition to the gantry crane already referred to, the storage ground for the mould boxes is served by a 7-ton derrick crane and a similar type of crane of 10 tons capacity serves the dressing yard. Throughout the yard, as also into the foundry, standard-gauge tracks are laid, and these are travelled by the company's locomotive so that trucks can be loaded or discharged at any desired point.

Installed at a time of great stress, it is small wonder that the foundry has been taxed to its utmost limits. Castings up to 70 tons can be made; and, as a matter of fact, the output for last year was approximately 20,000 tons, and it became necessary to lake extensions. The structural material to increase the length of the building by 85 ft. is now erected, and the extension will be entirely completed in the course of the next few weeks.

To serve the extension, a 10-ton electric overhead crane will be installed.



EXTENSION IN COURSE OF ERECTION. OFFICES ON LEFT IN REAR.

THE SCOTTISH IRONFITTERS' ASSOCIATION have lodged an application for an advance to time-workers of 15s. per week, and for a consolidation of wages and bonuses at present being paid. The Falkirk piece-workers' claims have been considered at a joint conference, but no decision has been arrived at.

AT a recent meeting of the status committee of the Society of Engineers, it was agreed that members should increase their fees (other than those charged as a commission) by 33⅓ per cent., and that the fees mentioned in "Professional Practice in Engineering, Part I., Consulting Engineers" should be altered accordingly.

The Carburisation of Iron at Low Temperatures.

By ANDREW MCCANCE, D.Sc., A.R.S.M. (Glasgow).

(*Abstract.*)

The object of this short note is to show how an insight into the reactions taking place can be obtained from the consideration of the variation of the equilibrium conditions with temperature. To begin with, pure CO tends to decompose according to the reaction

$$2CO = C + CO_2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

and the composition of the mixed gases at any temperature can be ascertained by passing CO_2 over carbon. The reverse reaction, however, is very difficult to bring about without the use of catalysts. Iron is one of these catalysts, and when pure CO is passed over iron decomposition starts with the deposition of carbon. The action is a surface action—it is only the gas in contact with the iron which is decomposed, but convection and circulation cause this decomposed gas to be replaced by fresh gas, and so the average content of CO_2 in the total volume gradually but slowly increases.

The composition of the gas at atmospheric pressure in equilibrium with carbon can be ascertained by means of the equation given by Carpenter and Smith and slightly modified for convenience, where x is the proportion of CO

$$\log \frac{x^2}{1-x} = 7.71 - \frac{8200}{T} + 0.0007\ T$$

and curve 1, Fig. 1, gives graphically the percentage of CO_2 plotted against temperature. At 650 deg. C. it will be seen that the composition of the gas is 61.5 CO_2 and 38.5 CO, giving a ratio $\frac{CO_2}{CO}$ of 1.60.

As the gas in contact with the iron undergoes this slow enrichment with CO_2 at different times, depending on the amount of CO_2 present, other reactions are possible and will take place within the limits of composition assigned to them. By drawing a diagram of the CO_2 percentage and the temperature for each reaction the chemical changes taking place can be very readily seen. This diagram is given in Fig. 1. Curve 1, as already explained, gives the compositions for equation (1).

The next reaction which can be considered is the formation of cementite—

$$3Fe + 2CO = Fe_3C + CO_2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

and using the same symbols as before, the equilibrium constant is

$$K = \frac{1-x}{x^2 P}$$

Schenk gives the value of $\frac{1}{K}$ at 650 deg. as 31,600, measuring P in millimetres, and this has been used to calculate the composition at any temperature from the equation—

$$\frac{d \log K}{dt} = -\frac{Q}{RT^2}$$

equation (2) are given by curve 2, and they show that at 650 deg. C. a gas containing 2.3 per cent. CO_2 is in equilibrium with cementite and iron. The proportion increases rapidly as the temperature is lowered, and at 575 deg. C. it is roughly 19 per cent. If less than the equilibrium percentage be present at any temperature, then cementite will be formed, while if more, cementite already formed will be reduced again. The percentage varies with the pressure as well, and when less than atmospheric the percentage is also reduced. Under normal conditions it will only be in the very early stages of the process that cementite can be formed from iron direct through the action of pure CO.

As the CO_2 content increases a stage is reached when the iron is oxidised by the mixed gases according to the reaction—

$$Fe + CO_2 = FeO + CO \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

which is independent of the pressure. At 650 deg., if the gases contain more than 42 per cent. CO_2, the iron will be oxidised to FeO.

Near the surface of a piece of solid iron in pure CO the CO_2 percentage will rise rapidly owing to reaction (1), and the CO_2 will then diffuse away into the surrounding gas, but if the percentage gets over that required by equation (3) before it diffuses, then ferrous oxide will be formed, and this in spite of the fact that the average composition is below the requisite amount.

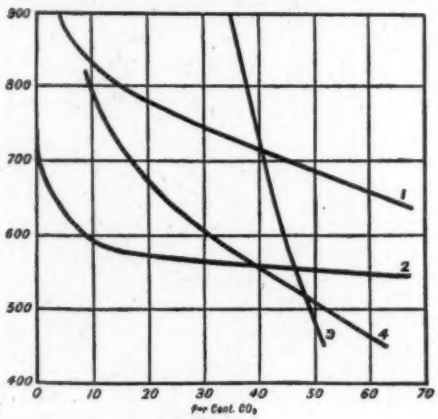


FIG. 1.

Ferrous oxide can be converted directly into cementite by the action of CO, however,

$$3FeO + 5CO = Fe_3C + 4CO_2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

and the composition curve for the mixed gases has been drawn in curve 4.

The striking result shown by this curve is that above 550 deg. C. ferrous oxide is more easily converted into carbide than pure iron. At 650 deg., for instance, pure iron can only be converted into cementite when less than 2.3 per cent. of CO_2 is present in the CO, whereas ferrous oxide can be converted up to 23 per cent. CO_2. Under normal conditions, when the iron will be exposed to the action of air in the gases to which it is exposed, the limits for the formation of cementite will be the limits in the composition of the gases for reaction (4).

In blast-furnace gas the presence of free air assures the presence of ferrous oxide, while the nitrogen lowers the partial pressure of the carbon gases. Thus, although the equilibrium value of CO_2 for reaction (4) is 23 per cent. under atmospheric pressure, when the gases are diluted with 55 per cent. nitrogen the value is reduced to 20 per cent. In the original report of Byrom, the blast-furnace gas had a $\frac{CO_2}{CO+CO_2}$ ratio of from 18 to 17 per cent., which is well under the equilibrium value. Such gases would therefore be expected to carburise iron at any temperature below about 660 deg. C., while below about 500 deg. C. the rate at which the actions take place would be so low that no appreciable effect could be observed.

Curve 1.—$2CO = CO_2 + C$.
" 2.—$3Fe + 2CO = Fe_3C + CO_2$.
" 3.—$Fe + CO_2 = FeO + CO$.
" 4.—$3FeO + 5CO_2 = Fe_3C + 4CO_2$.

Fourth Report of the Corrosion Committee of the Institute of Metals.

By Guy D. Bengough, M.A., D.Sc., and O. F. Hudson, D.Sc.

(*Summary.*)

The report is divided into three main parts. The first deals with the question of the nature of the actions that take place when metals such as zinc, copper, aluminium, and alloys such as 70 : 30 brass, corrode in neutral or nearly neutral liquids, e.g., distilled water and sea-water. The second section is devoted to the consideration of the behaviour of condenser tubes in similar liquids, and the variations in behaviour in different samples of tubes of nominally the same composition. In the third section an attempt is made to set out in some detail a statement of the practical problems of corrosion, which appear to the authors to be very different from what is usually supposed. A preliminary account is also given of experimenets carried out with the object of testing an electrolytic (the Cumberland) process of protection, and a pre-oxidising process.

Causes of Condenser Tube and Ferrule Corrosion. (*Water side only considered.*)

Cause.	How produced.	Nature of action.	How to be remedied.
A. Foreign bodies carried in and accumulation of products.	A1. By ferric hydrate flakes from water ends. A2. By ashes, clinkers, etc. A3. By sludge of sorts in water supply.	Complete corrosion or the I oxide disintegration type causing local action.	A1. Paint the pipe line and water ends. Inc ease water speed. A1, A2, and A3. If worth while trap the water supply or pass it through a screen. In some cases increase water speed.
B. Acid or other bad or variable water supply.	B1. Some river supplies, *e.g.*, Tyne. B2. Some canal supplies, *e.g.*, ship canal. B3. Some well supplies. B4. Some estuarine supplies. B5. Some cooling tower arrangements	Complete corrosion and rapid general thinning. Sometimes slight uniform dezincification.	Keep water supply slightly alkaline. Use special tubes adapted to the special conditions.
C. Temperature in condenser too high.	C1. Hot inlet water, *e.g.*, tropical. C2. Slow water speed. C3. Partial blocking of tubes.	C1. Dezincification. C2. Dezincification. C3. See A3.	C1 and C2. Use special tubes. C2. Increase speed. C3. See A3.
D. Undue aeration.	D1. Errors in pump and pipe line arrangements. D2. Eddies near inlet causing waterline effect.	D1. Complete corrosion of oxide disintegration type. D2. Complete corrosion of pitted areas.	D1. Remedy air leaks, etc. D2. Special ferrules. Possibly increasing speed of water with modified design of water end.
E. Unsuitable composition of tube.	E1. Zinc or impurities in too great amount. E2. Surface of tube not sufficiently copper rich.	E1. Varies. E2. Dezincification.	E1. In manufacturing. E2. Probably by attention to details of annealing and pickling during manufacture.
F. Defective packing of tubes.	F1. Leaks caused by perishing of the packing material, especially in acid water. F2. Collapsing of tube.	F1. Varies. F2. Varies.	F1. Use good tape packing. Red lead is sometimes useful to prevent leakage. F2. Do not crush tube when inserting it.
G. Physically bad surface of tube ; *e.g.* bad spills and laminations.	G1. Foreign bodies caught and trapped which would otherwise be swept away.	G1. Complete corrosion and oxide dezincification.	G1. During manufacture.
H Thermo-electric action in condenser.	H. By steam impinging directly on tubes, or being improperly distributed.	H. Dezincification.	H1. Only occurs in condensers of old design when steam is not properly distributed.
I. Too slow water speed.	I. Gases given off inside tube and not immediately swept away.	I. Complete corrosion near inlet end.	I. Increase speed of water. Do not use main condenser for auxiliary machinery import.

Part I.—Nature of Corrosive Action.

The current theories of corrosion are briefly considered. The difficulties in the way of making a true quantitative determination of the amount of corrosion are discussed, and shown to be almost insoluble in certain cases with existing methods of analysis. Mere "loss of weight" measurements, unsupported by detailed analyses of scale and metals in solution, are considered to be of little value in many cases, and might be replaced with advantage by microscopic work.

The action of distilled water on metallic zinc has been studied in some detail, and the following conclusions have been reached. Metallic zinc is normally covered with a partially protective scale, which consists largely of oxide or basic carbonate. Water containing CO_2 can attack or dissolve the oxidised layer, and zinc can then be found in solution as a slightly soluble bicarbonate. The attack on the scale begins at certain points, and a true metallic surface is exposed to the action of the water. At such places a peculiar form of oxide is formed on the surface of the metal. Probably this oxide contains zinc peroxide, and exerts a catalytic action on the underlying metal. It is slightly soluble and passes into solution, and is afterwards largely precipitated as the ordinary hydroxide and carbonate. The precipitated hydroxide has a distinctly protective action on the metal beneath it, and reinforces the original scale and enables it to resist the action of CO_2. The action is thus localised. In the presence of very large amounts of CO_2, as, for instance, when the water is kept saturated by bubbling CO_2 through it, the products of corrosion are largely kept in solution and local action is almost entirely avoided, though the total amount of corrosion that takes place is increased. This is due to the fact that almost the whole of the original scale is removed by the solvent action of the water, with the result that further oxidation of the metal can take place, and further solution.

In the case of very dilute acid, such as acetic, the action consists in the replacement of hydrogen by zinc, but the action is not severely localised as in the case of distilled water; there are no local accumulations of the products of corrosion, and consequently the action is much more nearly uniform. There is no evidence that dissolved oxygen can act as a depolariser; hydrogen

is given off as gas. The authors come to the conclusion that the initial action of distilled water on zinc is a process of chemical oxidation rather than electro-chemical displacement. The action of sea-water on zinc is also chemical rather than electro-chemical, and local action in this case also is due to the local accumulation of the products of corrosion.

The action of distilled water on copper is also chemical oxidation. There is no preliminary electrolytic action, even in the case of a surface of metallic copper known to be free from oxide previous to immersion. The oxide formed over the general surface immediately after immersion is a lower oxide, either Cu_4O or Cu_2O. In course of time it becomes further oxidised at irregularly distributed spots, and the product thus formed does not protect the underlying metal from oxidation to the same extent as does the original tarnish layer. The dark oxidation product itself, which is probably a cupric hydroxide or basic carbonate, tends to flake off the metal, probably owing to the formation of bulky oxidation products beneath it. The latter are porous, and apparently amorphous, and probably act catalytically by increasing the rate of oxidation of the underlying metal. The amorphous oxide is slightly soluble, but is finally precipitated from solution as crystalline cuprite, which has a lower solubility than the amorphous oxide. The result of the action, continued in time, is to cause shallow pits in the metal. Such pits are much less important than in the case of zinc. In the case of some further experiments, however, this pitting action was not developed, and the only action that could be observed was the formation of thick layers of oxide over the whole surface of the metal. These layers do not necessarily remain of uniform thickness over the whole surface of the specimen, but pronounced local action does not occur. In rare cases appearances are found on metallic copper, which the authors have only been able to interpret on the assumption that they are little electrolytic cells, but the phenomenon is so rare that it is unimportant in comparison with the main action already described.

The principal action of sea-water on copper is again one of chemical oxidation. The action may be localised by the accumulation of the products of corrosion, under certain conditions. It has been found that the aeration of one of a pair of copper electrodes causes that electrode to be slightly electro-positive to the other. The effect on the rate of corrosion of the E.M.F. so set up was, however, found to be quite small, and less than the effect of other physical factors, such as the rate of flow of the corroding medium and the degree of aeration. The conclusion has been formed that differences in the rate of oxidation have a greater effect on the amount of corrosion than small differences of potential.

A number of experiments have been made to ascertain the effect of coupling together electrodes of different metals, and immersing them in different electrolytes. The behaviour of such couples was by no means always such as would be expected from electrode potential lists. In some cases the couple behaved in the reverse way to that which was expected, and in others the effect of the couple in increasing the corrosion was much less than expected. The effect of a couple is greatly decreased if the contact between the electrodes is not very carefully made. It is probable that the effect of couples in some of the practical problems of corrosion has been overemphasised rather than the opposite, as sufficiently good contact for large effect does not usually occur. It has been definitely established that a metal may be oxidised and pass into solution in spite of the fact that it has been continuously maintained as a cathode, and the laboratory result has been confirmed on the practical scale by experiments carried out with an electrolytic protection of condenser tubes (the Cumberland process).

A preliminary study of aluminium and certain light alloys in distilled water and sea-water has been carried out. Local severe pitting at or near the water-line is described and discussed. It is shown to be due to the presence of a strongly acid salt.

An attempt is made to introduce a definite system of nomenclature into the terms used in the study of the corrosion of binary alloys, in order to avoid the confusion which at present obtains. In certain cases precise definitions cannot yet be formulated, as in the case of 70 :30 brass, owing to the difficulty of distinguishing between residual metal and redeposited metal.

The nature of the action of distilled water on 70 : 30 brass has been studied in detail by means of the microscope and analytical methods. The action is considered to be the chemical oxidation of the copper and zinc, and the partial solution of the oxidised products. Most of the zinc passes into solution, in the presence of CO_2, and part of the copper, the remainder of both metals remaining on the surface of the alloy as an oxide scale. The scale becomes further oxidised and altered at certain spots which become covered with thick deposits of the products of attack. Such deposits are porous and allow, and probably accelerate, local attack on the underlying metal. The attack is accompanied by redeposition of copper by displacement by the zinc either electro-chemically or otherwise, and precipitation of cuprite. There are signs of slight local dezincification at such places, but the attack over the general surface of the alloy is complete corrosion. The positions at which local attack and pitting take place are not determined by the variation in the electrical properties of the original metal, but by the conditions of the experiment. In the presence of dilute acids, such as HCl and H_2SO_4, local action of the type described does not occur, since there is little or no local accumulation of oxidation products. On the other hand, the absence of CO_2 retards the action. From the analytical data it appeared that the local action in the case of distilled water increased with time, while the rate of general corrosion over the whole specimen fell off. These facts suggest the fallacy of loss of weight tests, since local action is more important practically than general corrosion.

The action of sea-water on brass has been studied on the same lines as that of distilled water. The action is considered to be similar in type. Local pitting and dezincification are due to the accumulation of the products of corrosion. Under certain conditions redeposition of copper may occur. The rate of corrosion is much greater than that in distilled water, and does not fall off so rapidly with time. At the ordinary temperature there is less tendency to local dezincification.

Part II. - Corrosion and Protection of Condenser Tubes.

The form of the surface of certain condenser tubes of 70 : 30 brass has been studied in detail. The presence of a layer that differs in its behaviour towards corrosive agents from the underlying metal has been identified in several different ways. In many cases this layer is probably richer in copper than the alloy beneath it. In such cases the tube may resist dezincification in a marked degree for long periods; in other cases the surface layer probably has nearly the same composition as the rest of the tube, and in such cases strong dezincification may take place in sea-water at about 50 deg. C. Tubes from the same batch of manufacture usually resemble one another as regards the nature and properties of the layer, and tubes from different batches, even though made by the same maker, may differ. Thus an important factor as regards dezincification is the nature of the tube, but the kind of surface that best resists dezincification does not necessarily best resist other kinds of attack. Means of controlling the surface layer have not yet been worked out, but the problem does not appear to be insuperable, and is receiving attention. The condition of the surface layer should be adapted to the conditions under which the tube will be used.

In many cases local action may be initiated on condenser tubes by the action of certain bodies, which themselves appear to take no direct part in the action.

Such bodies are sand, calcium carbonate, ferric hydrate, glass, clinker, and coke. The amount of action that takes place varies with the physical properties of the substance. The action is associated with the accumulation of products of corrosion, and may be largely assisted by them. The nature of this action is of well-marked type, and has been provisionally called oxide disintegration. It is usually characterised by intercrystalline oxidation. Actions of this kind are of great importance in many cases of corrosion on the practical scale.

A preliminary study has been made of the action of very dilute acids on copper, 70 : 30 brass, and Admiralty alloy. The matter is important technically, because supplies of water in certain parts of the country are slightly acid. The strength of acids used were between 5 and 10 parts of acid in 100,000 of water. Both HCl and H_2SO_4 were used. Acids of these strengths greatly accelerate corrosion and alter the type of action. The attack of the two acids, even when of equivalent strength, differs both in extent and character, that of HCl being greater and more selective. Admiralty condenser tube was decidedly more resistant than 70 : 30 brass to the action of dilute acids.

Part III.—Notes on Practical Problems of Corrosion.

This part of the Report deals with the subject of corrosion under practical conditions as it appears to the authors. The views expressed are founded upon their general experience both in the laboratory and in connection with working conditions on actual plants. Unfortunately, the conditions in a practical plant are never known in full detail. Evidence as to the cause or causes of corrosion rests on a comparison of the corroded tube with others which appear to be similarly attacked under conditions that are more precisely known. One degree of probability, therefore, which attaches to these views must be regarded as lower than that based on conclusions drawn from laboratory experiments.

The authors express the view that corrosive attack on condenser tubes is more diverse in character and more complicated than has been generally supposed. The first action is one of chemical oxidation, and, secondary actions are of great importance. No one single remedy is likely to be found effective for all the different kinds of attack which occur in practice. The nature of the tube used and the protective measures chosen should be dependent on the particular set of conditions.

The following is a set of conditions under which a 70 : 30 brass condenser tube should have a minimum life of twenty years:—(a) Only clear water to enter the tube, or water which will not deposit suspended matter. (b) The water must be free from gases in suspension, and must not contain more than the normal amount of air in solution. (c) The water must be neutral or not more than very slightly alkaline. It must be free from ammonia and certain other specially harmful substances, which are, however, of comparatively rare occurrence in technical waters. (d) The temperature of the cooling water in the hottest part of the condenser should not exceed 35° C. (e) The speed of the water should be about 5 or 6 ft. per sec. (f) The steam should be properly distributed in the condenser, according to the best modern practice. A water supply which varies considerably in composition at different times of the year involves special problems and must be excluded from the above statement at present.

In practice tubes fail sooner than the period stated, because the normal slow roughening of the tube by chemical oxidation is locally speeded up by factors which are for the most part independent of the tube. This way of treating the subject is the inverse of that usually adopted. A preliminary attempt is made to gather the more important of these factors into a tabular statement, which is given herewith. The statement is to be regarded as a skeleton structure, which will be emended and filled in as experience accumulates. In practice factors set out separately in the table may act jointly. Causes of corrosion are not arranged in the table in order of importance, since this order varies in different types of installation. The effect of water speed on the rate of corrosion is briefly discussed; its effect varies with the type of corrosion.

The effect of the presence of a scale on the rate of corrosion is considered to be of great importance. Of the substances that commonly occur in scale calcium carbonate is one of the most important. Its effect varies with its physical condition. It may exert almost any kind of effect from a considerable degree of protection to a serious attack.

Some observations are described on the effect of a form of electrolytic protection (the Cumberland process) at the Southwick Power Station of the Brighton Corporation. The conclusion is reached that the process ensures a prolonged life for the tubes under Southwick conditions, provided that it is applied to new uncorroded tubes. The process should be applied continuously and not intermittently. The authors consider that the thin uniform scale which is maintained on the tubes by the process is an important factor in preventing serious corrosion. One of the important functions of the scale is to prevent contact between the tube and harmful deposits and products of corrosion; in addition it slows down, but does not entirely prevent, the general oxidation of the tube. The authors consider that further evidence is necessary before the value of the process can be estimated as regards prevention of corrosion in certain kinds of water other than seawater. Other possible methods of protection are briefly considered, and a preliminary account is given of a pre-oxidising process for reducing the rate of corrosion.

HUME PROCESS.—We had occasion to refer to the Hume process for making pipes which are stated to oust cast-iron pipes in South Africa and Australia. A Tasmanian paper now reports that the first of the 600 concrete cylinders to be used instead of wooden piles in the construction of the wharf inside the new breakwater at Burnie, for the accommodation of deep sea vessels, was turned out recently by the Hume Pipe Company, the contractors for the work. The firm's plant has been installed in the blockyard at the harbour, and the proceedings were in the nature of a trial. The concrete cylinders are 10 ft. long by 4 ft. 6½ in. in diameter, the concrete being 12 in. in thickness. To produce them a steel cylinder is placed on four wheels, and driven by an electric motor, revolving at the rate of from 250 to 300 r.p.m., the concrete is thrown in, and the centrifugal force thus produced gets rid of the water. It takes about a quarter of an hour from the time the mould is set in motion until the concrete cylinder is ready for removal, which is then lifted to a storing place by a crane. Three 12-in. pipes can be turned out in seven minutes. The firm make down to 4-in. pipes, and the moulding cylinders revolve at a much more rapid rate for the smaller work, decreasing in speed with the increase in the size of the pipe. To obtain the necessary height in constructing the wharf, the concrete cylinders will be placed on top of each other, cemented together, and secured by an 8-in. steel band on the outside at the joint. The hollow space in the cylinders will be filled with sand. The Home Pipe Company have secured orders for large quantities of concrete piping. The Ladysmith Municipality have ordered 5,400 ft. for 250 lbs. working pressure. Gold mining companies have ordered piping for pressures from 150 lbs. down to 50 lbs. Other orders have come in from country districts for culverts, drains, etc. A further consignment of new plant has arrived, which will enable the works at Germiston to be doubled in size and output. Some excellent test results have been obtained with pipes. Two lengths of 4-in. pipes jointed together with a Hume collar joint have been tested to 360 lbs. per sq. in. without showing any signs of leakage or sweating.

Wear and Tear of Large Gas-Engine Parts.

The subject of suitable materials for wearing parts of internal-combustion engines has been so much to the front of late, and is so intimately associated with the question of cast iron, that the following particulars will be of considerable interest to foundry readers :—

In the course of a Paper on the "Installation and Working of Large Horizontal Gas Engines," read at a meeting of the Cleveland Institution of Engineers recently, MR. H. PILLING (Manchester) submitted data based upon replies received from various firms to questions addressed to them regarding the actual amount of wear and tear noted by them in their large gas engines. It was pointed out that the firms in question had had several years' experience with large gas engines of the horizontal type, and that the said engines had not included many improvements recently effected.

CYLINDERS.

Firm A. About 0.03 in. of wear per year on diameter (at the worst point).
Firm B. About 0.15 in. per year.
Firm C. About 0.04 in. per year. Re-bore after 7 years.
Firm D. Been running up to 9 years without re-boring.
Firm E. About 0.02 in. per year.
Firm F. Average wear 0.03 in. per year. Liners last five years before requiring re-boring or renewing.

PISTONS.

Firm A. Require renewing after 4 to 5 years, owing to ring grooves becoming too wide.
Firm B. Indefinite life. (Cast iron pistons of medium size.)
Firm C. Cast steel, same experience as Firm A. Life of cast iron piston (old type) uncertain; average 15 months.
Firm D. Indefinite life (Cast iron).
Firm E. No sign of failures after one year.
Firm F. Average life three years, but improved pistons have so far shown no signs of failing. All pistons of cast iron.

PISTON RODS.

Firm B. Re-turn after six years. Wear about 0.04—0.05 in. per year. (Measured on diameter.)
Firm C. Life 6 to 8 years. Wear 0.06 in. per year.
Firm D. Mostly not yet re-turned after 8 to 10 years.
Firm F. Wear about 0.01 in.—0.02 in. per year.

PISTON RINGS.

Firm B. Life 1½ to 2 years. Wear 0.25 in. of thickness per year.
Firm C. Life 1½ years.
Firm D. Life several years.
Firm E. Wear about 0.03 in. of thickness per year
Firm F. Life nine months.

STUFFING BOX RINGS.

Firm B. Life 4 to 5 years.
Firm F. Life very variable; anything up to two years. Depends on condition of piston rod. Hot piston rod generally destroys the packing.

GAS ENGINE CLEANING PRACTICE.

Firm B. Wash out cylinder, cylinder cover and exhaust inner casing jackets every three months. General internal inspection every six months.
Firm C. Wash out cylinder jackets every six months.
Clean stuffing boxes every 4 to 6 weeks.
Attend to ignition plugs every 4 to 6 weeks.
General inspection every 12 months.
Firm D. Wash out cylinder jackets every three months.
Clean exhaust valve seats every six months.
Clean inlet valve boxes every five to six months.
Clean stuffing boxes every nine to twelve months.
Firm F. Wash out cylinder jackets and cylinder cover every 10 to 12 weeks.
Clean exhaust valve seat jackets about every 4 weeks.
Clean inlet valves every 8 to 9 weeks.
Clean governor gas valves and hand regulating valves every 4 to 5 weeks.
Clean gas stop valves on cylinders every 8 to 10 weeks.

Summary of Replies re Gas Engine Troubles.

LARGE ENGINES.

Firm A. Fracture of piston rods at couplings, due probably to misalignment.
Leakage of water from piston rods past internal fittings.
No other troubles.

MEDIUM ENGINES.

Firm B. Exhaust valves were at first water-cooled and troublesome. Not water-cooled now and are satisfactory.
Cylinders of single-piece design fractured.
Cover and Exhaust valve boxes fractured due to defective castings.
Materials must be of the best. Gas must be clean and free from tar and dust.

MEDIUM AND LARGE ENGINES.

Firm C. Cylinders (built up); no troubles. Pistons cracked. New designs have effected improvement.
Stuffing Boxes.—Old type gave much trouble with hot rods. New design gives no trouble and runs much longer without cleaning.
Exhaust Valve Seats and Boxes.—Trouble experienced with the joint of the seat to the cylinder of the old design.
Firm D. Exhaust pipe fractures due to undue rigidity and unequal expansion.
Firm E. Exhaust pipe fractures as Firm D. New type ready, but not yet at work.
Firm F. Troubles generally due to the heating up of the piston rods in the stuffing boxes.
No serious difficulties experienced.

The statements and data given above, the author continued, indicate that during the past decade when the general status in respect of improved manufacture had not attained to the high point prevailing to-day, even such maintenance charges as are indicated by the returns do not seriously reduce the dividend-earning capacity of a gas-engine installation.

Dividing the responsibility of upkeep between the makers of the engine and the users of the engine, the position is as follows:—

The makers are responsible for:—

(*a*) The general design and suitability of the engine as a whole.
(*b*) The materials used in the manufacture of the engine.
(*c*) The workmanship used in the engine.
(*d*) The erection of the engine.

In respect of workmanship, particular care requires to be paid and the utmost degree of perfection attained to ensure the absolute dead alignment and squareness of the crankshaft with the engine and of the cylinders, and various guides. In particular, the piston rods and cross-heads must be axially perfectly true with each other and with the cylinders in which they work.

The users of the engine are responsible for:—

(*a*) Providing clean gas at the right temperature (Hot or dusty gas should be unthinkable.)
(*b*) Good soft water. This should be regular in quantity and at a satisfactory temperature.
(*c*) Lubricating oil, regular and of right quality and quantity.
(*d*) Systematic cleaning of gas pipes and water jackets.
(*e*) Systematic inspection and cleaning of cylinders and valves to remove dirt, carbon and other deposits.
(*f*) Proper maintenance of spare parts, ignition plugs, spare exhaust valves, piston rings, piston rod pack-

ing rings and such other details as are necessary to secure the requisite continuity of operation.

(*g*) Closing up brasses, preventing knocking, and in particular maintaining true alignment of the piston rods, in the event of the slide blocks wearing or the foundations settling.

In conclusion, the author mentioned some of the special features which had been developed or introduced in recent years.

(*a*) Adoption of built-up cylinder with liners to eliminate casting and expansion stresses.

(*b*) New method of fitting piston rod whereby the position of the piston on the rod is adjustable. This is of great value when dealing with spare parts, inasmuch as any spare piston or rod can be accurately fitted in position so that the piston rings come exactly to the edge of the bell mouth in each case, although the cylinder dimensions may not in each case exactly coincide.

(*c*) New type of piston rod packing, whereby the whole packing is much more accessible for cleaning, overhaul, inspection and repair, without the necessity of removing same from the rod.

(*d*) New type of exhaust valve box, with renewable valve seat, and also special arrangements for detecting any leakage between the exhaust valve box and the cylinder body. This is calculated to save in many cases the renewal of a cylinder.

(*e*) New arrangement of exhaust pipes and new design of expansion joint, with a view to avoiding fracture.

(*f*) New type of piston free from bending stresses. With this type of piston the liability to fracture due to bending stresses is greatly reduced.

(*g*) New frictionless air valve for blowing cylinder. This valve is even superior to certain well-known German valves.

(*h*) Improved arrangement of powerful servo-motor governor for the electric generating engines.

(*i*) New arrangement of ignition switch board, with visible indication of correct functioning of all igniters.

(*j*) Improved and simplified inlet valve arrangement.

The Webb Electric Steel Furnace.

According to "The Iron Age," the principle of the Webb furnace is a radical departure from the usual practice. It has been the custom of engineers to design furnaces to operate on low voltages. In most cases 100 volts or thereabouts have been found best. It has, of course, been realised that if a higher voltage could be used without sacrificing good working conditions and results, an advantage would be gained in the size and the consumption of electrodes, the amount of copper necessary in bus bars, etc., the adjustment of the arc, and in general a less cumbersome furnace. The fundamental principle or way in which the arc is formed or fed in transferring electrical energy to heat has not favoured the use of high voltages in furnaces of familiar types, except the single-phase furnace using a single electrode.

The Webb furnace is supplied from a balanced three-phase source of electricity. The voltage on the secondary side of the transformers is 280 at a maximum, but the arrangement is such that this can be reduced when it is advisable to cut down the heat at the end of a melt. A single arc is formed among three electrodes and the bath, the arc stream acting as a conductor of electricity, forming a multiple conductor with the bath or material to be melted. The arc being long, on account of the high voltage, automatic control is not found necessary. Though an advantage in some respects, automatic controls get out of adjustment and require careful attention. Other conditions being equal, the length of the arc is proportional to the voltage, and inversely proportional to the current for a given power input. If one works with an arc normally 1 in. long and the electrode be moved a quarter of an inch, evidently the power input will be materially affected, but if working with an arc 6 in. long and the electrode be moved a quarter of an inch the effect will be hardly noticeable. Therefore, it is that while working with low-voltage arcs automatic control is necessary, whereas with high-voltage arcs it is not so essential.

The basic-lined furnace makes a heat in from 2½ to 3 hours. The electrode and power consumption are very low. An interesting point is that, so far as the arc is concerned, the voltage can be increased to values quite too high on account of insulating troubles, etc., and still give good operating results. For several months the furnace was run at 440 volts, using as a power supply a bank of transformers made by grouping a number of standard pole-type lighting transformers together.

An example of the working of the Webb furnace is afforded by the following record of three heats made last May, in the original furnace :—

Heat.	Charge. Lbs.	Ingots— 6 × 6	Ingots— 7½ × 7½	Kw. hours. per ton.	Time Hours
1	6,800	11	6	616	3½
2	7,000	12	6	583	3½
3	7,180	12	6	474	2

The following results have been obtained from tests made on electric engine-bolt steel (0.12 per cent. carbon and 0.50 manganese) :—Elastic limit, 39,500 to 43,220 lbs. ; tensile strength, 53,540 to 63,700 lbs. per sq. in. ; elongation in 8 in., 28 to 32 per cent. ; reduction of area, 51.2 to 64.8 per cent.

POWER IN CHEMICO-METALLURGICAL INDUSTRIES.—Professor Flusin, in a recent issue of "Métaux, Alliages et Machines" has published an interesting table on the uses of electrical power in metallurgical and chemical industries, which summarises, for many products, (1) the kilograms of product obtained per kw.-day consumed; (2) the kw.-days consumed per metric ton of manufactured product; (3) the tons of raw material used to manufacture a metric ton of product; and (4) the kilograms of raw materials used per kw.-day consumed. Professor Flusin has compiled these tables for the purpose of eliciting other views on the subject, and to encourage the publication of similar tables for other products.. We reproduce a portion of the table herewith :—

Product.	Kilograms obtained per kw.-day used.	Kw.-day consumed per metric ton manufactured.	Tons raw material used per ton of product.	Kilograms raw material used per kw.-day consumed.
Aluminium	0.8–0.9	125–111	3.0	2.5
Pig-iron	10	100	Variable	Variable
Synthetic iron ..	24–30	42–33	1.3	36–38
Steel in solid form ..	22	45.5	1.3	27
Steel in liquid form ..	120	8.3	1.3	150
Electrolytic iron—rotating cathode ..	6	167	1.1	7
Electrolytic iron—fixed cathode ..	23	43.5	1.1	25
Ferro-silicon, 10-12 per cent. Si ..	9.2	109	1.55	14.3
Ferro-silicon, 25-30 per cent. Si ..	5.8	172	1.90	11.0
Ferro-silicon, 45-50 per cent. Si ..	3.0	333	2.90	8.7
Ferro-silicon, 70-80 per cent. Si. ..	1.4	714	4.30	6.0
Ferro-silicon, 90-95 per cent. Si ..	1.0	1,000	6.40	.64
Ferro-manganese, 18-20 per cent. Mn. ..	15	67	1.80	27
Ferro-manganese 70-75 per cent. Mn. ..	6	167	3.15	19
Ferro-chrome, 10 per cent. Cr.	3.5	286	2.90	10
Ferro-chrome, 1 per cent. Cr.	1.8	555	4.05	14
Ferro-tungsten ..	2.5–3.5	400–286	2.7	7
Silico-manganese, 10 per cent. Si, 20 per cent. Mn. ..	7.5	133	2.2	16.6
Silico-manganese, 10 per cent. Si, 70 per cent. Mn. ..	4.6	217	2.5	11.4
Silico-manganese, 25 per cent. Si, 50 per cent. Mn. ..	3.0	333	2.7	8.0
Silico-calcium ..	1.5	667	•	•
Silico-aluminium ..	1.0	1,000	•	•

• No data.

D.

Heat Treatment of Tool Steels.

Prevention of Hardening Cracks.

Mr. S. N. Brayshaw, of Manchester, in a Paper before the Birmingham Metallurgical Society recently, dealing with "The Heat Treatment of Tool Steel," said that there was a great deal more yet to be learnt about carbon tool steel, and especially as to how it was affected by heat treatment before hardening. Nor did he think that the final annealing or heat treatment of tool steel was yet properly understood. Dealing with a research of his which was still in progress, Mr. Brayshaw mentioned that he got two large ingots cast specially, and the analyses of the two came remarkably close. It was satisfactory to find that Sheffield steel-makers could produce two large ingots so much alike. The analysis, representing a standard tool steel, was as follows:—Carbon, 1.13 per cent.; silicon, 0.14; manganese, 0.37; sulphur, 0.027; phosphorus, 0.022; chromium, 0.19; tungsten, 0.54 per cent. The chromium made little difference, and its presence was probably unintentional. The cooling curve showed a halt at 738 deg. C., and this was so consistent that they used the quenched steel to standardise their pyrometers. The point of recalescence on re-heating was usually about 716 deg., but depended upon the maximum temperature. From this steel a large number of bars were made. In the physical tests a great variety of results was obtained when the hardening treatment varied, whilst with bars submitted to the same hardening treatment, but to different previous heat treatment, the results also were most irregular. This showed that the whole question had not been sufficiently investigated. It was desirable, if possible, to apply these results for the assistance of the practical hardener who had to deal with difficult tools which were liable to crack or to change shape in hardening. He had therefore made a large number of test cutters of designs which had been found to be specially liable to hardening cracks.

Showing a group of such cutters after hardening, Mr. Brayshaw said that he had a regular system of naming these hardening cracks and assigning marks to them according to their badness. They wanted to find out how to make uniformly sound cutters, and he believed that they were on their way to that goal when they produced particular cracks and found out what regularly produced each kind of crack. He had a number of these cutters in various stages, and every cutter was being treated by a different process, whilst all were hardened as nearly alike as possible. For the first few hundred cutters he devoted a great deal of attention to the various hardening methods and temperatures, and with rising or falling heats or long soakings. He had the best success with the cutters which were raised just above the yield, then cooled to just above the recalescence point, and finally quenched in water. But he found that the best results in the avoidance of hardening cracks might be obtained by the suitable preparation of the steel before hardening.

Referring to a cutter of a design peculiarly liable to cracking, Mr. Brayshaw said that he had known something very remarkable to occur in connection with a cutter of that kind. They used to buy a great quantity of carbon steel, and when bars of 2¼-in. diameter came in they used to make from them cutters of this design, harden them by a moderately severe process, and then observe the kind of cracks which ensued. In one case the cutter hardened without a crack when treated by the standard treatment he had referred to. That remarkable result he was convinced must have been due to the condition of the steel when it left the steel-makers. There was probably nothing remarkable in the analysis, but the steel might by pure chance have gone through a process which gave it very unsual properties. The question might be asked what was the final treatment of such steels before they left the steel-maker. The maximum temperature might vary, and also the time the steel was subject to that temperature. The manner of annealing was also subject to great variation; the steel might be kept a little above or a little below the change-point in the cooling down. Each of the factors was variable to an indefinite extent, and by a combination of them they got an enormous variety of possible terms. If one purchased steel from a good maker one might rely upon a large degree of uniformity in analysis, Brinell hardness, and machinability. Yet amongt such steel there were great differences—of an elusive kind, but possibly of great importance. They ought to endeavour to discover a law which would enable the steel-maker to leave the steel in the required condition. Our knowledge of steel had been increased during the last dozen years, and yet we were only on the path of discovery.

The lecturer said that his experience had shown him that to obtain the best results it would be necessary to carry out heat treatment in liquids instead of in atmospheric furnaces. It was not possible in the atmosphere to regulate the process with precision. During heating the temperature of the muffle must be higher than the temperature to which it was wished to raise the work. This involved the over-heating of sharp corners and thin parts, whilst some of the steel near the walls of the muffle would be baked or soaked before the protected parts became sufficiently heated. Metal might be heated by contact with the gas or smoke as well as by radiation. That had some advantages, but there was also an increased risk of overheating corners and thin parts. In either case it was impossible to raise the temperature evenly, although the final heat might be uniform. The only way to avoid this was to raise the heat with a slowness that was seriously objectionable. The only ideal method was to immerse the tools for a given length of time in a liquid which was maintained at the proper temperature. The pyrometer then showed truly the temperature of the work itself, as nothing in the bath could have a higher temperature than the liquid. The bath could not vary rapidly in temperature or be caused to fluctuate by the opening or closing of a door, and when the heat was withdrawn the mass cooled altogether. The changes in temperature must be comparatively slow. There was nothing to prevent such a liquid being used for the heating of bars on a large scale, the process being the same as with small tools. Heating in liquids was very swift. People working on accepted lines said that this was objectionable. One so often heard it said that the articles should be heated slowly that it was assumed that there must be some virtue in slow heating. But this was another case in which people were misled by an expression which led to confused thinking. There was a similar confusion when a man said that a tool was too hard, really meaning that it was too brittle. The hardness in nearly all such cases was a good thing. Even a punch would be much better if it could be got glass-hard, and at the same time be as tough as if it had been tempered. On the other hand, if a man said a steel hammer was too hard he was using a correct expression. Ordinarily when one said that steel must not be heated too quickly, what was really meant was that it must not be over-heated on the outside, which was the result of swift heating as ordinarily carried out. If over-heating of the surface could be avoided, there was no objection to swift heating, and this was possible with heating in a liquid. He had had tens of thousands of articles heated from the cold in salt baths, and he believed that the effect of the swift heating had been good. The best results had been attained with very short heats, five minutes total time instead of half-an-hour. With these swift heatings he had got elastic limits running up to 6,000. The swift heating of a hardened tool might crack it, so that there the warning against swift heating was not out of place.

Macro-Etching and Macro-Printing.

By J. C. W. Humfrey, B.A., M.Sc., M.Eng. (Sheffield).

(*Abstract.*)

In carrying out investigations upon specimens of steel, with a view to determining either their suitability for any given purpose, or the causes which have led to their failure in use, a knowledge of the macrostructure is usually as essential as a knowledge of the microstructure. The two are complementary, the former affording information as to the history in the ingot mould and during forging, while the latter affords information as to thermal treatment and composition, and at the same time enables the details of the macrostructure to be correctly interpreted.

The macrostructure of a cast metal is essentially due to segregation whilst solidifying; and it is convenient to consider such segregation to be of two kinds, which may be termed major and minor. Both are the result of the fact that the first portions to solidify contain an excess proportion of the constituent having the higher freezing temperature, while the last portions to solidify contain an excess of the constituents having the lower freezing temperature.

Minor segregation is due to differences in composition which result between the portions of any individual crystal growing in the mass, and is unavoidable. By regulating the rate of cooling through the solidification range, the number of centres from which crystallisation starts, and hence the individual crystal size, may be largely modified. Each individual crystal, however, always tends to form with a gradual variation in composition from nucleus to boundary. Thus whilst minor segregation may result in a structure which is macroscopic or microscopic, it can never be completely eliminated at the casting stage.

Major segregation is due to the difficulty of ensuring that solidification shall proceed simultaneously from centres regularly distributed throughout the mass, and hence that the average composition of each crystal shall be the same. In practice the heat from the fluid metal has to be removed by conduction through, and radiation from, the walls of the mould; and thus crystallisation starts from these walls, and may be complete in places adjoining them, before it has even commenced in places removed from them. Aggregates of crystals may, therefore, be formed during the early stages of solidification having an average composition quite different from that of other aggregates formed at later stages. The phenomena of major segregation are further complicated by the shrinkage which takes place on solidification, and by the evolution of gases. solidification, and by the evolution of gases.

Two methods are available for revealing the macrostructure of steel—viz., sulphur printing and etching.

Sulphur printing, carried out either according to the original method described by Heyn and Bauer upon silk, or according to the more generally used method of Baumann, with the aid of ordinary silver bromide paper, is of very great use in studying the extent and position of the major segregates. Its capability of revealing the minor segregates, and therefore of giving information as to the individual crystals existing in the original ingot immediately after solidification, is, however, somewhat limited for the following reasons:—(1) Unless the sulphur content be high, the globules of sulphide are too widely scattered to map out a clear continuous picture of the dendritic interspaces. (2) Very great care is necessary to avoid even the slightest movement of the paper while in contact with the specimen, and also to ensure that the contact shall be uniformly close. Provided, however, that the sulphur content be high, and that all movements be avoided, a very fair picture of the original dendritic crystals can be obtained.

Macro-etching is usually carried out with the aid of one of the following solutions:—

(*a*) Solutions of nitric acid in either water or alcohol. This reagent is particularly useful for revealing the presence of fine flaws or cracks. These are best observed if, after fairly deep etching, the surface is wiped clean from all carbonaceous deposit and carefully dried with alcohol. The slight oozing which occurs from the flaws shows them in marked contrast to the general grey surface. To a certain extent this reagent brings out the major segregates, but is far more delicate in revealing carbon segregation, and especially any locally decarburised areas, than it is of revealing segregates of phosphorus and sulphur. The contrasts in this respect are best seen while the acid is still attacking the surface. Except in the case of certain alloy steels, which appear to contain immobile carbides, the reagent is not sufficiently delicate to reveal the minor segregates.

(*b*) *Heyn's reagent* (12 per cent. solution of copper ammonium chloride in water) etches on the whole in a similar manner to (*a*), but at the same time tends to stain the portions high in phosphorus to a brown colour. This staining is not, however, sufficiently delicate to reveal the minor segregations of phosphorus.

(*c*) Strong (10-20 per cent.) aqueous solutions of hydrochloric acid or sulphuric acid, usually employed hot. These appear to act by firstly eating out the sulphide inclusions, and subsequently by acting upon the larger surfaces exposed to attack where the inclusions occurred, by eating out the segregates as a whole, and leaving the purer portions in relief. The general effect closely follows that obtained by sulphur printing.

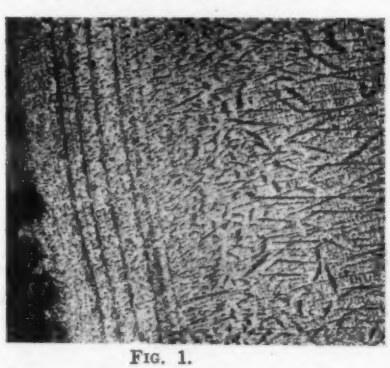


Fig. 1.

(*d*) *Acid Cupric Reagents.*—These reagents have been described by Rosenhain and Haughton, by Stead, by Le Chatelier, and by others. The solutions act by their power of differential attack on portions high or low in dissolved impurities, the attack being accompanied by a corresponding deposition of an adherent film of copper upon the surface of the steel. It is by means of this deposit of copper that the etching effects are judged. The reagents are remarkably sensitive, and are capable of revealing extremely small differences of composition such as occur between the various portions of a single original crystal. For the effects to be seen in the most favourable contrast the surface of the specimen requires to be given a fine polish such as given for micro work.

The reproduction of the results of any of the above methods of etching can only conveniently be done by photography; in the case of large specimens (*e.g.*, complete sections of ingots) the reduction in size which this involves is liable to mask the finer details of the etching—upon which a great deal of the usefulness may depend. In the course of an investigation into

the flow of the steel during the process of punching and drawing a shell blank, the author was successful in finding an etching reagent which, while having the delicacy of those mentioned under (*d*) above, could yet be applied to surfaces with an emery-paper finish only, and which allowed any number of exact full-size replicas of the etching effects to be obtained by a simple process of printing.

The solution is prepared by the addition of hydrochloric acid to Heyn's reagent, the most satisfactory composition for general use being :—Copper ammonium chloride, 120 grammes; hydrochloric acid (conc.), 50 c.c.; water, 1,000 c.c. The exact proportion of HCl appears to vary somewhat for different steels, but is easily determined by trial.

The etching is preferably carried out by supporting the specimen with the surface to be etched horizontal, and pouring on the solution at frequent intervals, so that a film of fresh solution is always in action.

The result of the etching is to produce a marked relief effect on the surface of the specimen, upon which the portions which solidified first are eaten out to a greater depth than the portions which solidified last; this relief effect is best seen after removal of the deposited copper. The addition of the hydrochloric acid causes the copper deposit to form as a continuous and somewhat adherent film, rather than as the loose flocculent mass left by the neutral solution. In the earlier experiments difficulty was frequently experienced in removing the deposit mechanically, and trials were made with various decoppering solutions to remove it chemically, but if the following procedure be adopted, the deposit can invariably be wiped away as easily as with the neutral reagent.

The etching is started with the neutral solution and is preferably continued with it until all traces of the scratches left by the emery-papers have been eaten away. To judge this it is necessary to wash off the deposit and examine the dried surface. When satisfactory in this respect the etch is again started with sufficient neutral reagent to form a complete but thin covering of the flocculent deposit, and then, in successive applications, the acidity of the solution is gradually increased up to the maximum. The attack is continued with this for about a quarter of an hour. The surface can be wiped free from copper at any stage and the effects of the etch examined, but after doing so the fresh attack should always be started with a preliminary application of the neutral reagent.

As stated above, the most favourable percentage of acid appears to vary somewhat for different steels. If insufficient is present, the relief effects are produced only slowly, and at the expense of a deep general attack upon the surface as a whole : if, on the contrary, the solution is too acid, there appears to be a somewhat vigorous attack upon the sulphide inclusions, which results in a deep pitting of the surface and a general spoiling of the whole effect. Alloy steels (*e.g.*, nickel-chrome steels) appear to etch better with solutions of weaker acidity than do plain carbon steels, indeed quite marked relief effects can occasionally be obtained on the former with the neutral solution alone. File- or machine-marks should always be carefully removed by rough polishing before starting to etch, since the general effect of the acid solution appears to be to deepen rather than eliminate them. If the surface has been prepared by machine grinding, it should be finally polished by hand, or deeply etched with the neutral reagent, until all signs of surface hardening are removed.

After wiping away the deposited copper, and drying, the surface has a general matt-grey appearance upon which the relief does not stand out very distinctly; if, however, it is lightly rubbed over with fine emery-paper, the relief portions are brought out into strong contrast, and the results of the etch are clearly revealed.

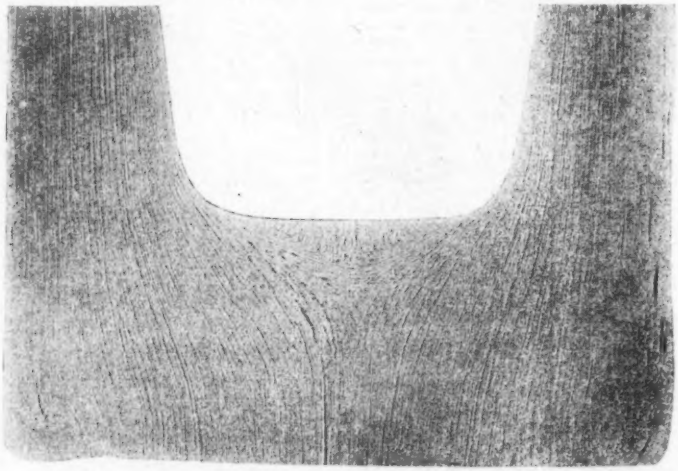


FIG. 2.

The total time taken to produce a satisfactory relief effect varies from about twenty minutes to one hour.

Printing.

The strong relief effects produced by the use of the acid solution suggested, at an early stage of the experiments, the possibility of reproducing the details of the etched surfaces by direct contact printing—*i.e.*, by means of printer's ink and a press. The illustrations of macro-etchings which accompany this Paper have all been so reproduced, the actual specimens being supplied to the printer.

The process of obtaining prints in the laboratory is as follows. The specimens are, when possible, machined into the form of slabs before etching, one of the parallel faces being that selected for etching. When a satisfactory etch has been obtained, ordinary printers' ink is applied to the surface by means of a roller. This is preferably of the type used by printers (covered by a special composition of glue and treacle), but results almost as satisfactory have been obtained

with a roller made in the laboratory by covering a piece of iron rod with a length of thick pressure tubing over it, and mounting in an old squeegee handle. A few dabs of printing ink are placed on a sheet of glass or tinplate, and the roller passed in all directions over the sheet until the ink is evenly spread out. Ink is transferred to the specimen by passing the roller alternately over the inked plate and the etched surface. The specimen is then placed face upwards on the base of an ordinary copying-press, the paper laid upon it, covered with a pad, and pressure applied. The best results are usually obtained upon what is known as "glossy art paper," while for general use the best form of pad is two thicknesses of blue "livery" cloth, such as is frequently used for covering polishing discs. For specimens upon which a very deep relief effect cannot be conveniently obtained, better prints can often be secured by the use of a somewhat harder pad, *e.g.*, a copy of one of the weekly technical journals.

For printing specimens too large for a copying-press, the paper may be pressed in contact with a heavy roller. Perfectly satisfactory prints have been obtained in this manner from the complete longitudinal section of a 1-ton ingot.

Interpretation of the Etchings.

Etched sections from unforged ingots appear to indicate, without any possibility of doubt, that the solution acts by attacking the purer portions which solidified first, with greater vigour than it does the more impure portions which solidified later. Etched sections from forged and treated specimens indicate with equal certainty that while the areas so differentiated may be deformed by the former process until the original dendritic pattern is rendered unrecognisable, yet the areas tend to retain their individuality in spite of any ordinary heat treatments, except such as are of abnormally prolonged duration, or are carried to temperatures approaching that of incipient fusion.

During the course of the last three years many specimens from all types of steel used in the construction of guns and shells have been etched in the author's laboratory, and only in those cases in which the microscope has given positive evidence of such incipient fusion or burning has there been any failure to reveal the casting structure or to obtain satisfactory prints by the methods described.

In view of the belief in the importance of phosphorus in mapping out the dendritic structures of steel, the author has been in the habit of referring to the prints as "phosphorus prints." It is, perhaps, inadvisable to do so until further experimental data are available, and the less controversial name of "macrographs" is suggested instead.

Examples.

In Fig. 1 the macro-print shows very clearly the manner in which the steel has crystallised in the ingot moulds, as regards the length of the crystals which

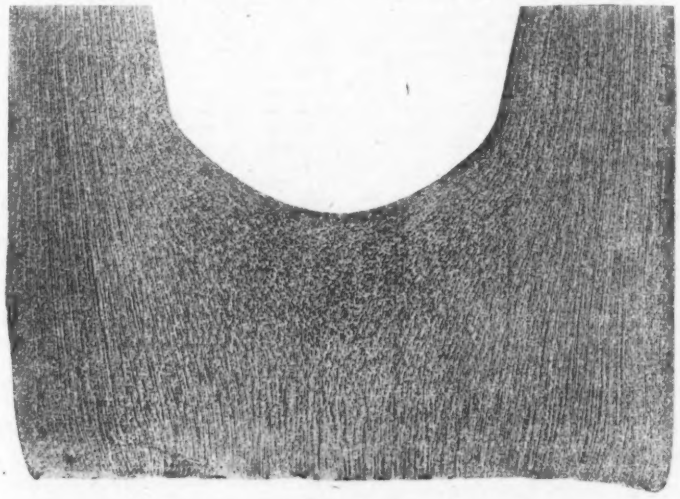


FIG. 3.

have grown inwards from the walls, and the shape and distribution of the equiaxial crystals which have formed within. The author considers that the skin has been formed owing to violent agitation of the liquid steel in the mould (probably due to too rapid pouring), successive skins being frmed above the general level of the molten steel. When once the skins have become submerged crystallisation proceeds in the usual manner.

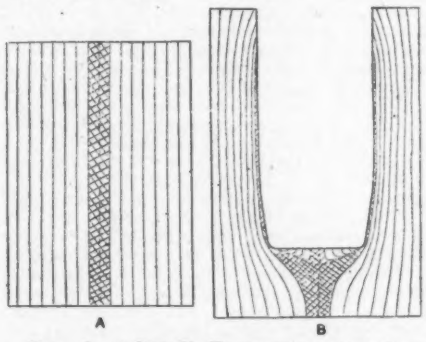


FIG. 4.—"CONE" FORMATION PRODUCED DURING FORGING.

Figs. 2 and 3 illustrate the use of macro-printing and etching in studying the flow of metal during forging. They are from longitudinal axial sections of the base portions of two shell blanks. In the case of the blank shown in Fig. 2 the punch used in forging had a flat face, and it will be seen that the flow has taken place in such a manner as to produce a curious "cone"

formation just beneath the base of the cavity. The manner in which this cone appears to be formed can be best explained by reference to the diagrams shown in Fig. 4. "A" represents a section of the blank before punching, upon which have been drawn a series of imaginary lines parallel to the axis. "B" represents the same billet after punching with a flat-nosed punch, and shows how these lines become displaced. A conical piece of steel from the top of the billet is pushed right down in front of the punch, practically without deformation; just beneath this undeformed portion the amount of lateral deformation suddenly rises to a maximum, so that a narrow axial cylinder in the billet is spread out to practically the full diameter of the punch. Below this maximum the lateral spread gradually becomes less, until at the base of the blank is again almost nil. In order to make the diagram somewhat clearer a central section has been cross-hatched in each figure.

In Fig. 3 the punch had been given a bluntly pointed nose (corresponding approximately to the outline of the cone in Fig. 2), and it will be seen that the cone formation is now entirely absent, and the steel has spread out regularly before the advance of the punch. These differences have been found to have a very important bearing in practice. In a completely sound billet the cone formation is probably unharmful, yet if the billet has any original axial unsoundness (*e.g.*, a minute pipe), a certain axial length of the defect becomes spread out so as to form a thin shell enclosing the cone, and the latter will then be only incompletely adherent to the base of the shell. One may compare the shape of a narrow axial cylinder in the billet before and after punching to a closed and open umbrella.

The pressure required to punch a billet with the form of punch shown in Fig. 3 is almost twice that required with the form shown in Fig. 2. This indicates that the surface friction between hot steel and cold punch is considerably greater than the combined resistance of the slip surfaces in the hot steel.

Improvements in the Rennerfelt Furnace.

At the beginning of 1918 there were about 20 Rennerfelt furnaces in operation on ferrous and non-ferrous metals in the United States. Instead of the original square or rectangular shape a round shell with a removable dome-shaped roof is now used, giving a more even heat distribution and a more accessible hearth. The vertical top electrode and the two inclined side electrodes have been retained. Heavier material is used in the construction of the furnace, and the electrode feeding gear has been much improved. All sizes of the furnace from one-ton capacity upward are now equipped with automatic side-electrode feed and auxiliary push-button control. The side electrodes are now adjustable in all directions and their ports are made air tight. The electrode-feed motor is made part of the holders. The furnaces of three-tons capacity and over are now equipped with a cradle and rack for tilting, and are no longer hung on central trunnions as before. Two new furnaces, to be installed for a special purpose, are equipped with a tilting fulcrum at the pouring lip.

The diameter of the hearth has been enlarged and the depth of the bath has been reduced in the various sizes, thus giving a larger contact surface between metal and slag, with consequent higher reaction speed, thus shortening considerably the time for desulphurising and "killing" in the basic steel process, thereby producing steel of a superior quality and with fewer slag inclusions and hard spots than before. In addition to this the steel is more thoroughly deoxidised and more refined. The electric power has been increased in proportion to the increased diameter, thus making the melting process more rapid and uniform. By actual experiments it has been found that the highest efficiency and best working condition in a free-burning arc furnace like the Rennerfelt are attained with a certain fixed, constant distance between the electrode tips and the charge. To carry out this the side-electrodes have been made tiltable and pass through specially designed ports with stuffing boxes to prevent air-leakage. At the same time the level of the electrodes has been raised, and thus the danger of breaking them during charging, slagging off, etc., has been reduced. All the side-electrodes are now made oversize. But the writers claim as the most important improvement that the side-electrodes can be tilted to such an angle that an arc can be formed with the slag. With the side-electrodes in this position, and the vertical electrode sufficiently lowered, the furnace can be worked as an arc-resistance furnace with the metal and slag as part of the circuit.

If any amount of refining is to be done, the electrodes are set in a way to make the furnace work as an arc-resistance furnace, which is a great advantage during the desulphurisation period in the basic process, especially when making tool steel. The authors also claim that the free-burning arc for melting cold scrap will assure an even and steady operation with a current demand from the high-tension mains perfectly balanced at a high-power factor. Noxious fluctuations and surges in the line are avoided, and the automatic electrode control can be used from the very beginning.

An Engineering Amalgamation.

The directors of Ruston & Hornsby, Limited, Lincoln and Grantham, have issued a circular to their shareholders informing them that after careful negotiations they have been able to arrange for the acquisition of at least 76 per cent. of the ordinary shares of £1 each in Ransomes, Sims & Jefferies, Limited, of Ipswich, in exchanges for the issue to the holders of such shares of a like number of ordinary shares in Ruston & Hornsby, as from January 1 last.

The business of Ransomes & Jefferies, incorporated in 1884, has been carried on successfully as mechanical engineers, chiefly in connection with agricultural implements and machinery, and the average rate of dividend paid by the company during the seven years ending on December 31, 1917, has been less than 1 per cent. lower than the dividends and bonus paid by the Lincoln firm during the seven years ended on March 31 last. The authorised capital of Ransomes is £750,000, divided into 250,000 5½ per cent. cumulative preference shares of £1 each, and 500,000 ordinary shares of £1 each. Of these shares 200,000 preference and 329,300 ordinary shares have been issued and are fully paid. In addition that company has issued £250,000 4½ per cent. first mortgage debenture stock, forming part of a total authorised issue of £300,000 first mortgage debenture stock. The reserve fund now stands at £200,000.

If the proposed arrangement is carried into effect Mr. George Ruston Sharpley will join the board of Ransomes, and Messrs. J. A. Goodwyn, J. H. W. Pawlyn, and V. W. Bone will represent Ransomes on the board of the Lincoln company.

Accompanying the circular is a notice convening meetings of Ruston & Hornsby, Limited, when resolutions will be proposed to adopt new articles of association and to increase the capital of the company to £2,500,000 by the creation of 900,000 new ordinary shares of £1 each. This is in excess of the number of shares which will be required to carry through the proposed arrangement, but the directors think it advisable to make this increase in capital at the present time in view of the possible requirements of the business in the future.

The Walrand Legenisel Converter for Small Steel Castings.

Small ton converters of the bottom blown type are not widely used in this country for the manufacture of small steel castings. The writer is not aware of another Walrand Converter being operated in England.

The converter, a drawing of which is shown in Fig. 1, is similar to the usual type—a plan cylindrical vessel built in one piece, except the removable bottom an wind box, and the mouth is tapered. The wind box and bottom are easily removed for ramming and are in one piece. A circular plate bolted to a flange contains six 6 in. dia. holes to admit the silica tuyers.

The tuyers are two feet long and are perforated with six ¼-in. holes, through which the air passes. The bottom containing the tuyers is rammed up

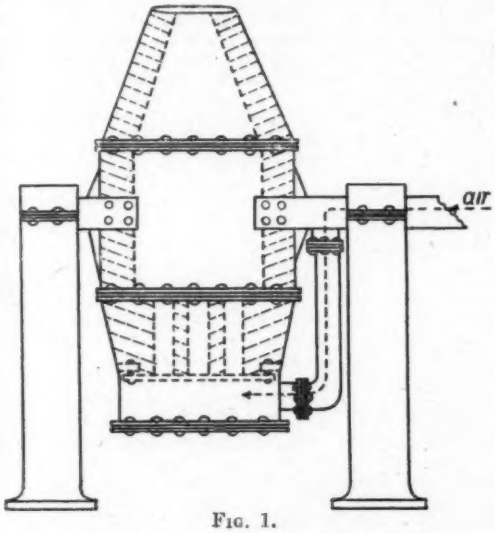


Fig. 1.

with fairly dry ganister, the ramming being continued up to the level of the tuyers. Large bricks may be used, the spaces being hard rammed. The finished bottom is then thoroughly dried before putting in position on the converter. The joint is rammed with ganister, which may be successfully carried out from the outside while the vessel is still hot from the previous day's run. By varying the number of tuyers, or the size of the holes, it is possible to vary working conditions to suit either rapid or slow blowing, and also the temperature of the finished steel. The blast pressure may also be governed to attain this result. The air pressure varies from 15 to 40 lbs. per square inch.

The bottoms last from 16 to 26 heats and can be changed quickly, there being no necessity to cool down the vessel for the operation. The ramming of the joint being done from the outside, it is possible to obtain steel each day. This is a decided advantage for small steel foundries, who as a rule work a single blown converter alternate days to allow the vessel to cool down sufficiently for the admission of a man to carry out extensive patching. In the Walrand vessel the principal wear occurs upon the bottoms. The blowing period occupies from 10 to 15 minutes, which is more rapid than the side-blown. The flame sequence is similar to the side-blown vessel, but there is very little "slopping" and the throwing out of large amounts of metal and slag, and the blowing losses are from 4 per cent. to 6 per cent. smaller. The carbon flame is quite distinct, but the final drop of the flame is not so rapid.

The physics—ferro-manganese and ferro-silicon—are added molten either to the ladle or, if pouring small castings, preferably into the converter. No difficulty is found in running very small castings with steel of 0.20 per cent. carbon, especially if the manganese is kept up to 1.20 per cent.

The life of the vessel lining will last up to 500 heats or more. The life of the lining, and especially the bottom, depends, upon the composition of the charges. A low manganese and high silicon charge will produce a thick, silicious slag which will hardly attack the lining. A high manganese and lower silicon charge will produce a thin cutting slag, rich in oxide of manganese, which attacks the refractory linings severely.

The charge composition found most suitable for obtaining hot steel for running small castings should contain 1.7 per cent. to 2.00 per cent. silicon and from 0.40 to 0.80 per cent. of manganese. This mixture tapped hot from the cupola works very uniformly. The first blowing period lasts from 3 to 5 minutes, with practically no flame showing from the converter mouth; sparks are emitted with the escaping inert nitrogen. The blowing engine is also slowed down with an increase of pressure. With the appearance of the carbon flame the molten metal offers less resistance to the air, with a considerable increase of engine speed and a drop in pressure. The carbon flame gradually rises to about 10 ft. At this period a few pounds of high-grade silicon are added if extra heat is required. Several small additions of silicon may be added without fear of the iron becoming oxidised.

Generally the outstanding features of the Walrand Converter are the comparatively low blowing losses, especially if worked in conjunction with a low air pressure cupola.

With careful working a loss of from 10 to 16 per cent. can be averaged. Taking the weight of metals charged into the cupola and the weight of molten seel obtained, this is much lower than the usual type of small converters operated in this country.

This system of bottom-blowing oxidises the iron immediately in contact with the incoming air, but the FeO gives up its oxygen to the carbon and escaping, lighting at the converter mouth as CO. Unlike the side-blown vessel, very little iron remains oxidised.

Charges varying from 14 to 30 cwt. may be blown according to the varying foundry requirements. The blows are very regular and easily controlled; boils and slopping rarely occur. It is also possible to cast several heats into one ladle for obtaining castings up to 4 and 5 tons owing to the short time necessary for blowing.

Steel can be made of any quality suiable for any tests.

Colonel O. C. Armstrong has been re-elected president of the British Engineers' Association.

Cast-Iron Automobile Cylinders.

An investigation into the charges brought by M. Robert Faroux against the use of cast iron as opposed to steel for cylinders of motor-car engines is made by Mr. J. E. Hurst in the "Autocar." He writes, commenting on an article by M. Robert Faroux dealing with statistics of car failures over a period of ten years' racing, the results of this careful statistical study show a high percentage of cylinder failures.

The question which immediately arises is: Are the failures of cast-iron cylinders due purely to defects of a metallurgical nature, or to defects arising out of the design? From the brief details given in this article it is gathered that the defects recorded are for the most part due to the latter cause.

Cast Iron and Steel Combined.

Cast-iron cylinders are for the most part *monobloc* castings, including water-jackets complete, and may comprise one, two, four, or more cylinders respectively. Apart from internal strains set up in the casting of such complicated units, the internal stress resulting from the changes in the material due to the prolonged exposure to varying temperatures in a racing engine are very large.

Cast iron, being an extremely brittle material, does not distort to any great extent before actually cracking. In the case of steel cylinders—considering for a moment a steel cylinder in the form of a *monobloc* casting—the internal changes taking place on subjection to the heat conditions in the engine are practically negligible; and in any case, owing to the higher degree of ductility, cracking is practically eliminated.

Foundry Difficulties and Steel Cylinders.

The difficulties of casting, however, and the extremely high cost, militate against the use of steel for *monobloc* cylinder castings; and now for the most part steel cylinders are constructed in the form of a steel cylinder liner inserted into either a cast-iron or an aluminium water-jacket casting, or, alternatively, the water-jacket is built up around the steel cylinder, using sheet metal, or by copper deposition processes.

It will obviously be unfair to contrast this form of cylinder construction with the *monobloc* casting.

Following upon aero engine practice, this type of cylinder construction is being largely adopted by various motor manufacturers. Opinion seems to be divided as to the correctness or otherwise of the use of cast iron for the purposes of the liner construction, and several of the firms adopting composite cylinder construction are utilising steel liners. In any event, the success or otherwise of the employment of cast iron for the manufacture of the cylinder liners depends entirely on the metallurgical nature of the cast iron used.

The use of cast-iron liners in this latter form of construction entirely avoids the trouble arising out of the presence of initial casting stresses due to the complicated nature of the casting. Research should, therefore, be directed towards the elimination of subsequent internal stresses as a result of internal changes of a metallurgical nature, owing to conditions encountered during the running of the engine.

The author has devoted a considerable amount of time to research work on this subject, more particularly in respect of the larger gas and Diesel engine liner construction. Several features have been established as a result of this study; and, since it is quite certain that many manufacturers do not seriously attempt to overcome the difficulties connected therewith, it may be of considerable interest to motorists and engine makers to enumerate these.

Growth of Cast Iron.

Cast iron, when subjected to prolonged exposure to heat, undergoes certain internal changes which in every case result in expansion, distortion, and in many cases cracking. These changes from the point of view of car-engine cylinders can be divided into two classes. The first class of internal change phenomenon has now come to be described as "growth." Growth in cast iron was exhaustively investigated by Professor Carpenter, now of the Royal School of Mines, in the year 1909. This phenomenon is a permanent expansion in cast iron when subjected to repeated alternate heating and cooling, and, in its chronic stages, results in the cracking and disintegration of the material exposed to the action of the heat. Professor Carpenter showed that growth was due to the internal oxidation of the constituents of the cast iron, chiefly the silicon, by the penetration of the oxidising gases into the interior of the cast iron by way of the graphite plates. The phenomenon was shown to commence at a temperature of 650 deg. C., and the liability of cast iron to this defect was shown to be roughly proportional to the silicon content of the material. In a perfectly running engine, temperatures of 650 deg. C. should never be reached (650 deg. C. is a very dull red heat easily seen in the dark). Theoretically, therefore, growth as such should be absent from automobile engine cylinders. This temperature, however, is undoubtedly reached, particularly in air-cooled engines, but, even in the present state of our knowledge it is quite possible to prevent any growth in the temperature ranges bordering on 650 deg. C. by suitable care in production of the material.

Cast iron, when subjected to prolonged exposure to heat in the lower ranges of temperature from 450 deg. C. to 650 deg. C., undergoes a permanent expansion, but in testbars of uniform cross-section this expansion reaches a maximum value without resulting in the cracking and disintegration of the material. It is quite conceivable that, in a casting of complicated cross-section, such as an automobile cylinder, such expansion will set up sufficient internal stress as to result in the ultimate cracking of the casting. The author has himself examined many automobile engine pistons of cast iron which have cracked across the head owing to this cause.

By suitable modification of the composition and methods of production, it is possible at the present moment to produce cast-iron liners free from any possibility of the latter phenomenon and also substantially free from "growth" at temperatures up to 700 deg. C., but methods of production are only applicable to plain cylindrical castings, and *monobloc* castings cannot be produced by this process.

Room for Improvement.

There is no doubt whatever of the triumph of built-up steel cylinders over existing iron *monobloc* castings. With the development of engine design, however, chiefly as a result of aero engine experience and the employment of cylinders in the form of steel or cast-iron sleeves inserted into aluminium water-jacket castings, there is no reason whatever why cast iron should not give as good results as

steel even at the present time, and, as research progresses, there is no doubt that cast iron will be considerably improved beyond the high standard that it has now attained.

Finally, speaking entirely from a metallurgical point of view, there is still room in existing *monobloc* cylinder castings for considerable improvement. The author has examined several *monobloc* castings (not of an English make) in which all existing knowledge regarding the internal changes of cast iron when subjected to heat conditions had been totally disregarded.

Refractory Materials Section of the Ceramic Society.

Meeting at Middlesbrough.

The spring meeting of this Section of the Ceramic Society was held on May 22 and 23 at the Hall of the Literary and Philosophical Society, Middlesbrough, Sir W. J. Jones, Deputy-Controller of Iron and Steel Production, Ministry of Munitions, presiding. There was a big muster of members from various districts, as far apart as the London and Glasgow neighbourhoods. The proceedings commenced with cordial expressions of welcome from the Mayor of Middlesbrough (Mr. Joseph Calvert, J.P.), and from Sir Hugh Bell, C.B., the chairman, and Mr. John H. Amos the general manager of the Tees Conservancy Commissioners, which were acknowledged by Sir W. J. Jones.

The reading of the Papers was then proceeded with.

In discussing Prof. Boswell's Paper (see last week's issue, p. 702), Dr. A. Scott mentioned that mica schist was recorded to have been used for such purposes in Sweden as early as in 1740, and since then, but at lower temperatures than those employed in the States. It has also been used in some other countries.

Mr. Chance's Paper (see last week's issue, p. 684) provoked a rather lively discussion, in which Mr. Hamilton, Mr. Cosmo Johns, Major C. W. Thomas, and others took part. Mr. W. Hamilton remarked that his firm required some refractories to stand under very severe conditions, and they were prepared to pay "any price within reason" for satisfactory articles.

In the discussion of the Paper by Mr. W. J. Rees on "The Salts Extracted from Coal by Washing" (see last week's issue, p. 694), Dr. Mellor suggested the possibility of water containing definite amounts of certain substances in solution being more effective for washing the coal than the water used by Mr. Rees for the purpose.

A curious circumstance in connection with the Paper by Dr. Rosenhain and Mr. Coad-Pryor (see last week's issue, p. 685) was that the idea underlying the construction of their new recuperative furnace had apparently been applied already, for Mr. H. M. Ridge stated that a very similar furnace had been in use for some time, on a fairly large scale.

The meeting having adopted the report of the Committee on the British Refractories Research Association, that organisation can now be registered and start working.

Manufacture of Refractory Material During the War.

Sir W. J. Jones gave some remarkable figures from his Department's official records concerning the refractories made during the two-and-a-half years from July, 1916, to the end of 1918, all being for munitions only—except, perhaps, part of the silica sand. The percentages represent increases in production from July, 1916:—Silica bricks, 275,295,000 2½-in. squares, 45 per cent.; magnesite bricks, 15,089,900 2½-in. squares, 149 per cent.; coke-oven bricks, about 50,000,000 (150,222 tons), 110 per cent.; firebricks, about 1,200,000,000 (3,585,475 tons), 41 per cent.; raw dolomite 127,000 tons, 60 per cent.; calcined dolomite (basic material), 410,500 tons, 70 per cent.

The refractory materials industry had, he claimed, emerged from the war period in a stronger and more robust condition than ever before, and it should be possible for British industries to cease to rely on imports from either Allied or enemy countries. There could be no question of the advantages possessed by the home producer, having in view the heavy item for transport on refractory materials, so that, provided the manufacturers of this country produced an article equal to that formerly supplied from abroad, all should be well. He had just returned from a visit to the centre and South of France, and conditions as to labour and wages in the refractory materials industry of that country were much the same as here. In France wages in the industry had increased by at least 100 per cent.; in Lorraine workmen in the steel industry had received advances amounting to between 100 and 150 per cent. Moreover, the eight-hour day was now established by law in all these districts. He had inspected some of the French refractory works, and had been impressed by the extraordinary care with which the manufacturing operations were carried out. The clays employed, eight in number, were obtained from all parts of France. All the clay not previously burnt for grog was carefully dried on heated floors on arrival at the works, and was broken down through jaw breakers and steel crusher rolls and passed and re-passed through screens of different mesh to secure exactitude and regularity of grading. The grog was treated in a similar manner. The percentage of grog carried in the bricks often ran as high as 70 to 80 per cent., and the mixing was done with great refinement. He mentioned these facts to show how different was the method of working in France compared with that obtaining in this country.

It was necessary to make an effort to improve the technical side of our industry, and he made an appeal for support for the new Refractories Research Association which had just been formed, and which was an evidence of the spirit of co-operation in industry which now prevailed. The support of the Privy Council Committee for Scientific and Industrial Research had been obtained, and Dr. Mellor, the man most capable to direct the work of such an Association, had accepted the position of technical director. He appealed not only to manufacturers of refractories, but to consumers for their support.

The work that was to be undertaken was of great importance. It included a careful study of raw materials, of the chemical, physical and mechanical problems which had to be solved to obtain the best results in different kinds of service, the effects of various slags and impurities of molten metal, of acid and alkali reactions on the materials employed, the effects of variations of temperature, the erosive action of flue ducts, the cutting action of high-temperature flames, the effects of oxidising or reducing conditions, and many other considerations involving the careful study of such problems as conductivity, porosity, contraction, expansion, density, hardness, softening points, and effects of load. This brief summary of the work to be done would show of what great benefit to the industry as a whole such a Research Association could be if properly conducted and worthily supported.

Election of Officers.

In connection with the election of officers, etc., Sir W. J. Jones was, after a year's interval, again elected President of the Ceramic Society. Messrs. W. Hamilton, D. Sillars, — Whiteley, and Dr. A. McCance were added to the list of Vice-Presidents, and new members of the Council include Messrs. G. V. Evers, Cosmo Johns, and Cyrus Jones.

It was announced that the autumn meeting will be held at Stoke-on-Trent, the spring meeting of 1920 in London, and the autumn meeting of 1920 in the United States.

Pulverised Coal.

MR. LEONARD C. HARVEY has recently submitted to the Fuel Research Board a detailed report on the whole subject of the preparation and application of pulverised coal in America. This report has now been published by the Board as "Special Report No. 1" (H.M. Stationery Office), and we give herewith extracts therefrom. The Paper on the same subject, recently presented to the Iron and Steel Institute by the same author was intended as a supplement to the present Report, which is divided into six chapters.

In Chapter I. are set out the principles underlying the process, and a short description is given of the plant. A more detailed description of this and the equipment was given in his Paper just referred to, and is also given in Chapter III. Chapter I. also contains a discussion of the range of fuels which can be used by this method.

Range of Fuels.

There is no bituminous coal which cannot be burned in pulverised form. The ash content will be the determining feature as to whether a certain coal is to be recommended for any specific purpose, but, broadly speaking, any bituminous coal with an ash content up to 30 or even 40 per cent. can very well be burned in this manner.

There is now no difficulty in burning anthracite coals in sufficient volume. For the smaller sizes of furnaces it may often become necessary to mix a certain percentage of bituminous coal with anthracite, especially in locomotive work, owing to the limited area of the combustion chamber and the absence of any large body of hot refractory brickwork. The average annual output of the anthracite coalfields of Pennsylvania was, for the five-year period ending December 31, 1915, practically 70,000,000 tons. About 8 per cent. of this total output was hitherto considered as waste, it being of such a nature that its satisfactory combustion, either in hand or stoker fired furnaces, was not found possible. Its utilisation in pulverised form is, however, possible and practicable, and has been in use at a colliery in the Scranton district of Pennsylvania for about two years. Drying, pulverisation and handling is accomplished in the usual manner, the product averaging about 14 per cent. through a 100-mesh screen and 86 per cent. through a 200-mesh. No difficulty is experienced in handling, but the wear on the type of pulveriser in use is somewhat higher than when straight bituminous is being worked.

As regards lignites and peat, these fuels in their natural state contain a heavy proportion of moisture, but lignites are being successfully dried for efficient pulverisation, and have been used on locomotives with satisfactory results. While lignites can be burned on grates when used fresh after delivery, they rapidly disintegrate and become a mere heap of fine dust when exposed for any length of time to the weather. In the disintegrated state they can neither be burned on mechanical stokers nor upon hand-fired grates. For the purpose of burning in pulverised form, however, it matters nothing whether the fuel has been freshly delivered or has been reduced to a state of dust by weather. As with lignite, the chief difficulty in the treatment of peat for rendering it suitable for pulverisation lies in the heavy content of moisture to be driven off before it can be properly powdered. Peat in its natural state contains 90 per cent. of water, so that it becomes necessary to dry it by air or mechanically before delivery to the mill for final drying and pulverisation. Lignites and peat need not be dried to below 5 per cent. of moisture for efficient burning in powdered form. In fact, it is advisable not to dry lignite below this limit, otherwise the hydrogen and light gases in the fuel will escape to the stack before their combustion can take place in the furnace. Peat mixed with bituminous coal has now been used in powdered form in locomotives on the Swedish State Railways for some years.

Hard dry pitch can be pulverised in certain mills adapted for the purpose. In some instances it has been recommended to run one or two mills in series rather than to attempt final pulverisation in one mill. The heat generated is the more readily dissipated in this manner. A new method of obtaining the powdered or granulisation of pitch, to almost any degree of fineness, is by means of centrifugal force. The product is then in the form of minute spherical particles.

Gasworks' coke or coke breeze contains too little volatile combustible matter to be used by itself in the pulverised form. Coke in powdered form has been burned in some cases in America, but actual data are not forthcoming. The admixture of a small quantity of volatile bituminous coal to the coke breeze is a matter dependent upon the analysis of the coke. If anthracite culm of 8.30 per cent. content of volatile can be burned, straight, in locomotive fire-boxes, a by-product coke with a volatile content of 10 or 15 per cent., made in accordance with the object in view, should be a very useful fuel for burning under boilers or in metallurgical furnaces.

Steel Industry.

In repeating the opinions of users and owners, the names have been omitted.

Open Hearth Steel Melting Furnaces.—The advantages claimed are that pulverised coal can be applied with assured success, showing in some cases economy in fuel over producer gas firing with, however, no additional life of brickwork, but slightly the reverse. As regards range of fuels, a good grade is desirable, a suitable analysis being as follows:—Volatile matter, not under 36.00 per cent.; fixed carbon, not under 52.00 per cent.; moisture, not over 1.25 per cent.; ash, not over 6.00 per cent.; sulphur, not over 1.00 per cent. About 50 per cent. of the ash settles on the bath of steel and is tapped off in the usual manner. 30 per cent. to 40 per cent. should be deposited in the slag pockets provided for this purpose, and 10 per cent. to 20 per cent. will accumulate in the chequers, principally on the first few rows of brickwork.

Some of the opinions of users are:—(1) Would not recommend powdered coal in preference to producer gas, or coke oven gas of 500 B.T.U. For producer gas furnaces 6 million B.T.U. are used per ton of steel, for powdered coal furnaces from 6½ to 7 millions. (2) The tar and by-products make firing by means of producer or coke-oven gas more profitable. (3) Pulverised coal would be satisfactory for intermittent work, but for continuous output no time can be spared for cleaning out ash deposit in chequers and flues, if powdered coal were used. (4) For small plants where time permits the cleaning out work to be done, would recommend pulverised coal. (5) In relatively small plants results have shown a consumption of coal in powdered form of 540 lbs. per ton of steel as against 650 lbs. in gas producers. This gentleman was comparing his steel-melting plant of some 20 or 30 sixty- to two-hundred-ton furnaces with the relatively small plants. (6) Prefer tar to powdered coal; better heat and no trouble with ash. Powdered coal more economical than producer gas, but would prefer tar to anything. (7) Two 45-ton furnaces on powdered coal, two on tar heats with the former fuel take 8 to 10 hours, but 11 to 12 hours after cleaning out the chequers. Average coal consumption 422 lbs. per ton of steel, consumption of tar 45 to 50 gallons (American) per ton. Chequers with powdered coal firing naturally wear out more quickly than when tar or gas is used, the practice being to clean out one end after 40 to 50 heats, and the opposite end after the subsequent heat, the time taken to complete each operation being 2 hours. (8) Coal used to run under 1 per cent. sulphur, but now it takes more lime to counteract the increased percentage of

sulphur. No other trouble is experienced with the use of pulverised coal. The average sulphur and ash content of the coals then being burned showed :—Ash about 8 per cent., sulphur about 2.25 per cent. (9) For open-hearth furnaces using powdered coal would advocate the provision of three sets of chequers instead of the usual two sets. Average life of chequers before rebuilding becomes necessary, 150 heats, much of the brickwork being, of course, used again. (10) No severe cutting away of the furnace lining experienced, and can put in a new back wall in 2 hours after charging a heat. (11) Discarded producer gas in favour of pulverised coal on account of lower cost for running the plant and greater output obtained thereby. This has been definitely confirmed in practice, the monthly output with producer gas being from 10,000 to 11,000 tons and with the powdered coal furnaces 16,000 tons. (12) With powdered coal there is no necessity to burn out the flues as is the case with producer gas; this operation had to be carried out every three weeks, whereas it is now possible to run the coal-fired furnaces day in and day out for 150 heats. The writer also makes reference to the advantage derived from the use of pulverised coal in soaking pit, billet-heating, forge and other furnaces.

The German Steel Industry and Socialisation.

In a remarkable address delivered before the Verein Herr A. Vogler, President of this Association, touched upon the question of the socialisation of the iron and steel industry, which, in his opinion, must raise serious misgivings. The aim of the defenders of socialisation was to increase output and reduce costs; but to realise these aims a thorough knowledge of the craft and of its latest achievements and discoveries were essential. Socialisation must eventually end in the bureaucratisation of the industry, which would not be able to apply new theories to practice in the shops.

The workmen were pressing for a greater share in the profits; there was willingness to concede them, but the change could be brought about in quite another way, and without socialisation. An allied Association—the North-Western Group of the Association of Iron and Steel Makers of Düsseldorf—had been engaged for some time past in trying to arrive at a solution of the problem.

In a recent publication, Privy Councillor Deutsch had proved that even if the aggregate profits of sixty odd concerns, representing a total share capital of £125,000,000, were wholly surrendered to the workmen, there would only be an average increase in their wages of 11 pfennigs (1.3d.) per hour per worker, or 270 marks (£13 10s. at par exchange) per annum. These figures showed how unjust the accusation was about the exploitation of the workmen by capitalists, at any rate in Germany. On the other hand, the employers could not escape the blame for having allowed the guidance of their workers to slip out of their hands, and for not having devoted more attention, at the right time, to the enlightenment of their workmen as regards economic conditions. They had allowed them to fall into the hands of people whose interest it was to embitter rather than to smooth over any dissensions between masters and men. On the other hand, the institution of Works' Councils had developed to such an extent that co-operation between employers, trade unions, and works' councils appeared to be worthy of consideration and further study.

The President concluded his address by stating that unemployment would soon cease if everybody would fall in at his proper post and begin to work seriously. It was necessary for contract work to be done in all departments—contract work with the hands and contract work with the brain. This was the only way that would lead to maximum efficiency being obtained.

Mica Schist for Lining Cupolas and Steel Converster.*

By P. G. H. Boswell.

"Ganister" consists of a sloppy mixture of broken quartzite or ganister rock (*sensu stricto*) and fireclay or ground ganister. Such a mixture is used to a small extent in American foundries, but a large number of works employ a rock belonging to the mica-schist group, which is quarried in Pennsylvania and New Jersey, in each case not far distant from Philadelphia. The two chief localities for the rock are Glenside, north of Philadelphia, Pa., and Edge Hill, New Brunswick, N.J., and from these places, on the eastern seaboard, the material finds its way all over the steel-producing areas of the East and Middle West. The Glenside and Edge Hill rocks are very similar to one another, but the following description actually applies to the latter material, which is known commercially as "The Edge Hill Silica Rock Company's Mica-Schist."

In hand-specimens the rock is cream coloured and of clean appearance. Clayey and dusty minerals or decomposition products are absent. The rock, although foliated like all schists, is fine-grained and compact. Sections across the edges of the folia and cleavage planes are firm and compact, and joints break the rock cleanly and firmly across these planes. The surfaces of the folia are lustrous and silky with small plates of white mica (muscovite). Thin bluish bands interpenetrate the white folia and constitute about one quarter of the bulk. The rock is fairly hard, and even the foliation surfaces cannot be scratched by a knife without some difficulty. Nevertheless, the rock is easily split parallel to the folia and worked into the required shapes. A chemical analysis of an average sample of the rock, kindly carried out by Dr. H. F. Harwood, of the Imperial College of Science and Technology, London, S.W., is as follows:—SiO_2, 81.58 per cent.; Al_2O_3, 10.04 per cent.; Fe_2O_3, 2.24 per cent.; FeO, 0.32 per cent.; MgO, 0.19 per cent.; CaO, 0.22 per cent.; Na_2O, 0.08 per cent.; K_2O, 3.38 per cent; H_2O+, 1.74 per cent.; H_2O-, 0.27 per cent; TiO_2, 0.34 per cent.; CO_2, none; P_2O_5, trace; MnO, trace; BaO, 0.03 per cent.; Cl, trace. About 68.6 per cent. of silica is present in the free state, that is, in the form of quartz. The percentage of water driven off above 105 deg. C. ($=H_2O+$, 1.74 per cent.) is practically all accounted for as hydrogen in the muscovite, and combined water in the iron oxide.

Method of Use.—The rock is built by masons into the walls of converters and cupolas, inside the firebrick casing, in the usual way. The Edge Hill Company rightly insists upon the rock being set with the cleavage edges, and not the faces, forming the inner wall. The rock is obviously liable to chip and spall if the foliation planes are set parallel to the walls. Nevertheless, the writer saw several cases in the States where the rock had been so set, and the extraordinary thing was the successful way in which the material withstood the effects of hot metal. The schist is set in a mortar usually made from the local fireclays, but sometimes from the crushed rock itself. The company claims, and with good reason, that the rock is easily dressed, that it leads to the production of smooth walls, and that it does not easily cut back. To these qualities the writer can testify, but has no figures immediately at hand regarding the number of heats usually obtained from linings of this rock, nor any results which serve to show how far the quartz present has suffered inversion to cristobalite or tridymite. It is claimed that the rock glazes under severe heat, and that slag and clinker do not adhere to it. The glazing is inexplicable when we consider the quantity of potash present. Indeed the rock is, in practice, actually more refractory than its chemical composition would lead us to expect.

* Abstract of Paper read before the Refractory Materials Section of the Ceramic Society.

Some Criticisms by a Firebrick Manufacturer.*

By G. R. L. Chance.

As a manufacturer of what are commonly known as Stourbridge firebricks, it has been my ambition ever since I went into business to go in for more scientific methods of manufacture with the object of producing better quality bricks for various classes of work, and not necessarily the same brick for every class of work, as has often been the practice of not a few firebrick works in the past. With this object in view we built a laboratory at our works about five years ago, and we now have installed there an embryo chemist. I must confess, however, to a feeling of great disappointment and discouragement due to the attitude still adopted very prevalently by users of firebricks in this country, and at times I almost feel tempted to devote myself to the most economical production of the same quality firebrick which we have been making for 60 or 70 years with some success, and leave scientific investigation to others. I speak as a manufacturer of firebricks only, as distinct from any other kind of refractory material; I only speak from my own experience and I propose to be perfectly candid.

The first consideration of a business man is to make his business pay. The question then arises: "Is scientific research so far as it concerns the individual firebrick manufacturer going to pay him for the outlay expended?" The success of any business depends on three things: (1) The efficiency of the sales department; (2) cheapness or economy in cost of production, and (3) the quality of the finished product. In my opinion, in a firebrick business the first of these considerations is far and away the most important, and the last easily the least by comparison with the other two. I do not mean to imply that one's business is likely to be successful if one's goods are bad or inferior to most others on the market, but, given a reasonably good quality brick, I have as yet found comparatively little incentive from users of firebricks to improve the quality still further.

I should like to give one or two examples of what I call the lack of encouragement given to manufacturers to make an improved quality firebrick.

(1) In nine cases out of ten, where ordinary squares are wanted, an inquiry is sent out for "best quality firebricks," or perhaps "best quality Stourbridge firebricks" (I am, of course, dealing with inquiries in my own district). No specification is given and no details are given as to what particular work the bricks are wanted for. Generally speaking, the order is given to the firm quoting the lowest price, or, if the engineer or furnace builder has been in the habit of buying from one particular firm, a preference would perhaps be given to that firm of a few shillings a thousand; bricks 2s. 6d. per thousand more in price I have had described to me by a customer before the war as being at "a considerably higher price," and something wonderful was expected for this extra half-crown. I have also known a prospective customer say he did not mind paying sixpence a thousand more for a better quality brick. My point is that either a very ordinary quality firebrick is wanted where perhaps the bricks are not going to be used to destruction, where they are not expected to stand a high temperature and where they should stand for some years; in other words, where the quality of the brick is not really a primary consideration, or else the quality of the brick is really a consideration, in which case it seems absurd to split hairs over price.

(2) I think firebrick users are often very unreasonable in another way also. They frequently will not allow manufacturers a reasonable time to make the special firebricks they want. The result of hurrying large stuff is generally disastrous. Take, for example, blast-furnace lining lumps 6 in. thick and, say, 30 in. long. Unless they are dried slowly and burned slowly they will come out with black cores, cracked or warped. It is, I think, an unchallenged fact that the longer large bricks are given to dry the better they are, and that it is much better to set them in the kiln white hard. And yet time after time orders are held up for no apparent reason, and the bricks are then wanted in the minimum of time. Orders are often placed with firms who offer the quickest delivery, and for this reason the tendency is for manufacturers to offer quicker delivery than they ought to, compatible with the bricks being made properly. The result is that either the bricks are badly made or the stipulated time for delivery is exceeded. In either case the manufacturer gets blamed.

For some classes of work it is essential that the bricks should be very well burned and of good shape, and it is a puzzle to me why firebrick users still haggle over a few shillings per ton or per thousand instead of paying a slightly higher price and insisting on the best-quality brick. It is quite easy to make good and bad bricks with the same materials, but there is not always a strong incentive to a manufacturer to make the best brick if he is beaten down to the lowest halfpenny.

Here again, I think blast-furnace linings illustrate my point. Before the war thousands of tons of linings were made for 20s. per ton, or thereabouts. I defy any firebrick manufacturer to say that he could make a reasonable profit at that price, and yet blast-furnace managers will tell you that it is of great importance for the joints in a lining to be tight, the bricks to be evenly burned all through and to be perfectly flat, a standard of perfection which was often not reached with goods sold at three times the price.

While on the subject of blast-furnace linings I would like to know the real reason why some blast-furnace managers prefer comparatively small bricks 4 in. thick and about 14 in. long, and others insist on large bricks 6 in. thick, each brick weighing about 1¼ cwts. The reasons I have heard advanced are on the one hand that the smaller bricks are better burned, and on the other hand that it is preferable to have as few joints as possible, and the fewer the joints the less chance there is of a rock on the bricks when laid. As a matter of fact, if the bricks are made perfectly, the chief objections would be removed in either case, and the smaller bricks could be turned out twice as fast. A great deal could be done with a carborundum wheel to remove slight imperfections of shape and thereby to ensure tight joints.

(3) One occasionally meets with users of firebricks who insist on using firebricks coming from other districts for certain classes of work. When questioned they generally say, "Oh, we have tried Stourbridge firebricks often but they never last; we find those we are now using last longer, and we do not propose to make a change." I think it is a mistake for a firebrick user to take up that attitude; he should help the manufacturer to find out the reason for failure by giving him what information he can, and by offering to make tests of his bricks in actual use by building them in with other bricks and watching their behaviour. In tests I have found the analysis of two competitive bricks to be entirely different. In one instance I was told by the manager of a steel works that he had found another brick which would last six times as long for a certain purpose as our own brick which he had been in the habit of using for several years previously. I tested this brick in every way I could. It was machine-made, and owing to insufficient tempering or pugging of the clay there were longitudinal cracks and creases in the brick; it had a poor refractoriness (cone 28—29), it showed a contraction of 2.99 per cent., but it had an entirely different chemical analysis to our own brick. Added to this, the brick came from another district, and was cheaper owing to the clay from which it was made being worked in a quarry instead of a mine.

*Abstract of Paper read before the Refractory Materials Section of the Ceramic Society.

I do not think firebricks should ever be described as "first" or "second" quality at all. What is "first" quality for one class of work is "second" quality for another class, and *vice versa*.

There is still a great deal of prejudice amongst users. Take, for instance, machine-made firebricks. There are, of course, different kinds of machine-made bricks; but some users refuse to look at a machine-made brick of any kind for any purpose. Even wire-cut firebricks are quite as good and better than hand-made for certain purposes, though I still believe that hand-made are preferable in some cases. Perhaps some firebrick manufacturers will question this statement, as I believe there are works where all squares are now made by machine; but it is very largely a question of the nature of the fireclay. Some clays do not lend themselves to making good machine-made pressed bricks, though they may be all right for making wire-cut bricks. I am quite certain, however, that a wire-cut firebrick is decidedly inferior to a hand-made brick for some classes of work.

It has been said to me by more than one person eminent in what I might call the Refractory Materials world, that Stourbridge is losing its reputation fast, and if we don't put our house in order we shall soon be left out in the cold altogether. I have thought a good deal about it and have come to the conclusion that, compared to the general practice in this country, only in one way is Stourbridge behindhand, and that is in the type of kiln universally used throughout the district with one or two notable exceptions. I may say, however, that Stourbridge is not the only district by any means which is out of date in this respect. Fuel economy is really a national question, and it should be quite possible to save more than half the fuel used in firebrick works throughout the country if the question were tackled properly. For this reason I believe this is the most important question before the trade to-day, and I hope the Refractory Materials Section of the Ceramic Society will take up the subject seriously and without delay. I should like to see a committee formed to investigate all the different types of kilns in existence and try to come to some conclusion as to the best type of kiln for burning firebricks. Another subject I should like to see tackled without delay is the standardisation of patterns.

ACID RESISTING IRON APPARATUS. — According to a recent Paper by Mr. S. J. Tungay, presented to a meeting of the Manchester Section of the Society of Chemical Industry, on acid-resisting iron apparatus: —(1) The metal was not malleable or ductile, and could, therefore, only be produced in the form of castings. (2) If of correct acid-resisting quality it could not be turned, drilled, or screw-threaded, but was only machinable by means of grinding at high speeds with abrasive materials. (3) Owing to the very considerable shrinkage of the castings in cooling, it had been found almost imperative that all flat surfaces must be avoided, and vessels, instead of being flat-bottomed, should be well rounded. In the manufacture of pipes either flanged connections or socket connections must be adopted, as the metal could not be screwed or tooled in a lathe. Covers of vessels must be domed as well as the bottoms dished, and pipes and other similar castings should be so arranged that the cores were supported without chaplets. All cores had to be as stiff as they could be made, and particularly well supported in the prints so as to ensure clean and good castings. Flanges of pipes and vessels could be webbed, or filleted to the main body or surface of the casting, and bolt slots cored in flanges in preference to bolt-holes, which could not be drilled. Very satisfactory flanged connections had been made by casting lengths of pipe with a conical buttressed flange instead of a flat flange, cast-iron clips in halves being utilised to clamp the joints together. Buttressed joints were most satisfactory, as no part of the flange was liable to break off through irregular bolting.

Electric Steel Plant at Toronto.

In January, 1917, the chairman of the Imperial Munitions Board of Canada authorised the construction of ten Héroult electric furnaces at the plant of the British Forgings, Limited, located at Toronto, to deal with the large amount of steel turnings accumulating in all the munitions industries. The available power from Niagara Falls made the proposal a commercial possibility. Steel was made in No. 1 furnace in June, 1917, and the remaining nine furnaces were completed by August 18. The building is 610 ft. long, containing 27 bays of 22 ft. 6 in. each. The furnaces are of 6 tons' capacity, with tilting mechanism of the standard Héroult type, except that the lifting arms were lengthened 2 ft. to permit the erection of a steel brick-lined pan under the furnace shell, sloped toward the ladle pit so that, in case of a break through the furnace, no metal would reach the tilting mechanism, which is located directly under the furnaces. In front of each furnace there is a full-width opening in the charging floor for swinging the ladle, which is covered by a removable plate during the melting period. Electric power consists of three-phase 25-cycle 13,200-volt alternating current. The primary current entering the transformer room passes through electrolytic lightning arresters, 30,000-volt oil circuit breakers to 1,500 kva. water-cooled transformers. Each furnace has a transformer which supplies current at 100 volts, through delta connected secondary bus-bars and 18 flexible cables, six cables to each phase. Three electrodes are used per furnace, each 17 in. in diameter. The transformers run on rails, so that with the furnace tilted and cables disconnected they can be rolled out of the transformer room and handled by cranes. The furnaces are equipped with Thury regulators in the transformer room. In the rear of each furnace on the charging floor level is the furnace control switchboard, which carries the ammeters and the winch for raising and lowering the electrodes. The central bay of the transformer room is partitioned off, and contains the main switchboards for the control and service switches and recording and indicating meters. Directly under this control room, but on the casting floor level, is located the general service equipment, consisting of a 60-cell storage battery; 250-kw. and 300-kw. motor-generator sets for 230 volts, direct current; a 250-cub.-ft. capacity air compressor, oil pumps and electrical repair shop. Three 300-kva. service transformers are located in the transformer room. The scrap storage yard is 610 ft. long and has a capacity of about 12,000 tons. It is enclosed and commanded by two 10-ton 75-ft. span travelling cranes, each equipped with a 55-in. lifting magnet. The charging floor is extended into the storage yard so that scrap cars can be served by the yard crane. These 24-in. gauge cars pass from weighing scales to a point between the furnaces, where they are dumped and the material hand-charged into the furnaces. The plan of the plant affords excellent opportunity for a system of bins. A narrow-gauge track extends along the row of bins so that materials can be loaded into a car and conveyed to points underneath the hatches in the charging floor. An overhead runway for an electric hoist extends the full length of the transformer floor, for hoisting stock from the general storage bins to the charging floor. These works have recently been acquired by Baldwin's, Limited.

As a result of negotiations between the Gas, Municipal, and General Workers' Union and the employers in the cast-iron hollow-ware trade, the latter have undertaken as from April 1 to readjust piece prices in order to enable the average workman to earn 33½ per cent. on the day rate of 1s. 0½d. an hour, plus the bonus of £1 1s. 6d. and 12½ per cent. It was also agreed that all piece workers in the cast-iron hollow-ware trade should earn 33½ per cent. on their appropriate day rate.

The Annealing of Chains.

By J. E. Hurst.

It is customary in practically all works, factories, and foundries where steel chains are used for hauling, lifting, and slinging purposes to subject the chains to a periodical annealing treatment. The object of this treatment is to eliminate the fatigue strains set up in these chains as a result of their repeated subjection to stress. It is now common knowledge that the subjection of steel to repeated stress modifies the internal character of the steel in such a manner as to render the steel extremely brittle; and if the repeated stressing of the material is continued the material ultimately fractures.

The legal requirements as to annealing chains are not specifically stated as such in the existing Factory Acts. The Canels, Docks, and Wharves Act definitely requires the annealing of chains under its jurisdiction. In no case, however, is the actual treatment to be given the articles specified in detail. It is highly probable that the view taken of this matter is that the actual testing of chains up to their safe working load, which is distinctly specified, is sufficient to eliminate any defectively treated chains, and consequently is in itself sufficient safeguard against accident.

In the light of our existing knowledge it would appear that this view is not strictly correct. The actual submission of a chain to a steadily applied stress, and its failure to give any signs of fracture under such conditions, is not sufficient guarantee that the chain is perfectly sound. It has been shown that brittleness in steel may exist to a serious extent without any indications being given in either the ultimate strength or the ductility figures.
(Rosenhain & Hanson, Journal Iron and Steel Inst.)

This brittleness is only detected on the employment of a notched bar impact test or from an examination of the proportionality curve. It was also shown in this same investigation that steel after subjection to work developed brittleness, as revealed by the notched bar test, to a remarkable degree after annealing for a period at temperatures in the neighbourhood of the pearlite point (700 deg. C.) approximately. These same phenomena have been investigated by other workers, including Stead in this country and Chappell in America, and the results appear to show that the brittleness is brought about chiefly as a result of the excessive growth of the Ferrite crystals when annealed in this region of temperature after subjection to a certain degree of work. There is also every reason to believe that the brittleness reaches a maximum depending upon the extent of the work done on the material previous to annealing at these low temperatures.

It will therefore be fully appreciated that the actual testing of chains up to their safe working load, or even to destruction, does not necessarily give any indication as to their freedom from brittleness.

The anealing of chains is carried out in many works in a very unsatisfactory manner. It would appear to the writer that it is a prevailing conception amongst many engineers that it is sufficient for the chains "to be put through the fire." This question was brought to the writer's notice by seeing a chain annealed by heating in an ordinary blacksmith's hearth. This particular chain was annealed in stages of about 18 in. at a time until the whole had been through the fire. Annealing as carried out in this manner is most unsatisfactory, and, apart from the danger of overheating, which there certainly does appear to be every attempt to avoid, there is also the danger of not heating to a sufficiently high temperature, under which circumstances the brittleness phenomenon above mentioned might be anticipated.

Whilst the writer personally has never met with a chain that has failed, the danger of such indiscriminate treatment as that above mentioned cannot be over-estimated, and it appears necessary to point out, for the guidance of many engineers, works and foundry managers, and others, that the annealing of chains should be carried out by heating to the temperature of the upper critical point or just above—which for most steels used in chain manufacture is in the region of 850 to 900 deg. C.—and followed by cooling in air. Needless to say, it is necessary that the chains be uniformly heated.

The practice prevailing in certain works of subjecting chains to a prolonged soaking at comparatively low temperatures in the region of 800 deg. C. is not to be recommended, nor is it necessary to subject chains to a prolonged soaking at higher temperatures than this, followed by very prolonged cooling.

In conclusion it might be emphasised that the annealing of chains is a matter of sufficient importance to warrant it being carried out with scrupulous care, and, viewing the subject from the unsympathetic commercial standpoint, "it costs no more to carry out the annealing operation with scrupulous care than it does to carry it out negligently."

MECHANICAL PROPERTIES OF STEELS.—At a joint meeting of the British Foundrymen's Association, the Birmingham Metallurgical Society, and the Staffordshire Iron and Steel Institute, held recently at the Birmingham University, Mr. George Carrington presiding, Dr. Hatfield (Sheffield) gave the results of some recent experiments upon steel, the object of which, he explained, was to see if it was possible to improve the qualities of various steels and make them more serviceable for the particular purposes required. The special method adopted was to employ a great variety of tests so as to give every element of the steel a fair chance to show itself. The tensile test was extensively used, and they also made large use of the Izod test, the Stanton test, the Arnold test, and others specially devised to detect brittleness. In ninety-nine cases out of a hundred it was essential that the part that was made of steel should not be deformed on the surface, but it was possible for such tests to yield very little evidence as to how the steel parts would behave under stress within the elastic range. During the war a good deal of trouble was experienced with certain structural steels, and that was particularly the case where shell-discard steel had been used for the production of structural material. It was a remarkable fact that some of it stood quite satisfactorily until it was submitted to a different kind of test. In one instance it was found that the trouble was caused by an almost invisible crack which had been produced by a mistake in the mechanical treatment, and it was clear that a special kind of test must be devised to detect a defect of that kind. The speaker proceeded to give figures dealing with crank-shafts, tyres, cutlery steel, and forgings of different kinds, all of which illustrated his contention that it was impossible to know all about the qualities of different steels without submitting them to a much wider range of test than was now the practice.

Factors Influencing the Properties of Silica Bricks (Part 1.*)

By Alexander Scott, M.A., DSc.

The chief non-siliceous materials which occur in the rocks used in the manufacture of silica bricks are alumina, titanic oxide, iron oxide, lime, magnesia and alkalies, the amount of any one of them being generally less than 2 per cent. The object of this work is to investigate the effects of some of these on the inversion of the quartz to the high-temperature forms and on the properties of silica bricks.

The silica rock used was vein quartz of a fairly high degree of purity. The rock was broken up in a small steel crusher and sieved. Some of the material was treated with acid in order to see if much iron had been added in the crushing, but the amount extracted was negligible. For the making of the bricks the material which failed to pass a 4's sieve was rejected, and the remaining fractions taken in such proportions as to give practically a "straight line grade."

The bonding materials used were as follows :—A, Lime (CaO). B, Magnesia (MgO). C, Alumina (Al_2O_3). D, Iron oxide (Fe_2O_3). E, Iron oxide (Fe_2O_3)+carbon. F, Titanic oxide (TiO_2). G, Lime and magnesia. H, Lime and alumina. I, Lime and iron oxide (Fe_2O_3). J, Lime, iron oxide and carbon. K, Lime and titanic oxide. L, Magnesia and alumina. M, Magnesia and iron oxide. N, Magnesia, iron oxide and carbon. O, Alumina and iron oxide. P, Alumina, iron oxide and carbon. Q, Lime, iron oxide and titanic oxide. R, Glenboig fireclay. S, China clay. The materials were ordinary laboratory chemicals except in the case of the last three. The amount used was 2.5 per cent. in the case of the simple oxides; 1.25 per cent. of each where two oxides were used, while in Q 1 per cent. of each was taken. The carbon was ordinary charcoal, and the amounts in E were 2.5 per cent. oxide and 0.5 per cent. charcoal, and in J, N, P, 1.25 per cent. of each oxide and 0.25 per cent. charcoal.

The bricks were made in a vertical tile press, the approximate size being 2 in. × 2 in. × 1 in. After drying they were hardened sufficiently for transport by firing in a pottery kiln to cone 8, the duration of firing being 24 hours. The blocks were then fired for the usual period in a silica brick kiln to three different temperatures, cone 14, cone 16, and cone 19.

Micro-Examination.—The blocks fired to cone 19 were sectioned and examined under the microscope.

Conversion of the Quartz.—The factors which influence the conversion of the quartz include the nature and amount of the non-silicious materials present, the grain size of the quartzose material, the temperature of firing and the duration of firing. In order to test the effect of the second of these, the amount of residual quartz, left unconverted after 72 hours' firing, was measured microscopically in the case of blocks A and J, the firing temperatures being cones 14, 16 and 19. The results show that the conversion can be considerably increased if the firing temperature be increased. Since the rock used in this case was a pure quartzite, the conversion of which will in general proceed much more slowly than in the case of a ganister, the increase in conversion of the quartz in the latter is likely to be appreciably greater. The results show that the amount of conversion is greatest in the blocks containing lime or magnesia, and in general is higher in the former than in the latter. The addition of iron oxide to lime or magnesia gives a higher degree of conversion than does either of the latter alone, while alumina has a similar though somewhat smaller effect. Iron oxide alone induces a high conversion, but alumina on the other hand gives a low conversion. In general the conversion is greatest in those cases in which bonding material forms a relatively fusible mixture with the fine-grained silica of the matrix.

* Abstract of Paper read before the Refractory Materials Section of the Ceramic Society.

Specific Gravity.—The true specific gravity tends in most cases to vary directly as the firing temperature, while the apparent specific gravity follows similar lines.

Porosity.—From the results the blocks may be divided into two groups; one in which the porosity varies irregularly with the firing temperature, and a second in which it varies regularly. A, B, C, D belong to the former, and H, K, L, N, O to the latter. The two groups correspond to those in the case of the apparent specific gravities.

After-Expansion—The standard test specified by the Institute of Gas Engineers consists in heating a brick of known size to cone 12, maintaining it at that temperature for two hours, and then, after allowing it to cool, measuring the increase in size.

With regard to the results, the small expansions are found in the bricks in which the bond is a mixture of lime and iron oxide, while the next lowest occur in those in which these oxides are used separately. Magnesia gives a higher expansion than lime when used alone, and the same holds for combinations of these with alumina and iron oxides. Alumina and titanic oxide both give high values, but if another oxide is present in addition, the values are much lowered. The expansion in the case of the fireclay bond is low. The presence of carbon does not alter the after-expansion very much, but it is significant that in three out of the four cases tried, the bond containing carbon gives slightly lower values than the corresponding carbon-free bond.

Table I.—*Showing the Results of Refractory Tests.*

		Refractory cone	Approximate Equivalent temp.	Remarks.
A	CaO	33	1730	Squatted rapidly
B	MgO	33—34	1740	Squatted
C	Al_2O_3	36	1790	Did not squat
D	Fe_2O_3	36	1790	" "
E	Fe_2O_3+C	34	1750	Squatted "
F	TiO_2	35	1770	Did not squat
G	CaO+MgO	34	1750	Squatted
H	CaO+Al_2O_3	35	1770	"
I	CaO+Fe_2O_3	34	1750	"
J	CaO+Fe_2O_3	33—34	1740	"
K	CaO+TiO_2	34	1750	Squatted slowly
L	MgO+Al_2O_3	34	1750	" "
N	MgO+Fe_2O_3+C	35	1770	" "
O	Fe_2O_3+Al_2O_3	35	1770	Did not squat
P	Fe_2O_3+Al_2O_3+C	35	1770	" "
Q	CaO+Fe_2O_3+TiO_2	33—34	1740	Squatted "
R	Fireclay	36	1790	Did not squat

Spalling.—In general the bonds containing magnesia give somewhat lower values than those containing lime. The addition of carbon to the bond seems to increase the ratio, as the values for D, I, M and O are lower than those for E, J, N and P respectively. The values for alumina and fireclay are high, while those for the bonds containing TiO_2 are low.

Refractoriness.—The tests for refractoriness were carried out by the usual method. The results are collected together in Table I. In the case of those blocks which contained lime or magnesia as one constituent the softening is due to the fusion of the mixture of silicates and fine-grained free silica in the matrix. Where the bond consists of alumina or iron oxide, or a mixture of the two, the matrix and rock fragments seem to fuse simultaneously, and the softening point of the piece is practically the same as that of silica. The absence of squatting is due to the high viscosity of fused silica. Fireclay acts in a very similar way.

A reunion of those members who have been demobilised from the Army was recently held at the Rotherham Branch of the Friendly Society of Iron Founders, when a presentation was made to Mr. Samuel Hird, who has this year completed fifty years of membership with the F.S.I.F., and for forty years has been Check Steward of the Rotherham Branch.

Parliamentary Notes.

Machine Tool Department.

LIEUTENANT-COLONEL SIR J. NORTON-GRIFFITHS was informed on Monday by THE FINANCIAL SECRETARY TO THE MINISTER OF MUNITIONS that the Machine Tool Department of the Ministry of Munitions, which had been greatly reduced owing to post-Armistice conditions, had been amalgamated with the remnant of the Department which dealt with gauges. It was intended that the combined section should be housed in one building. The administrative head of the section was an engineer with large commercial experience. Certain members of the staffs of both of the old Departments were being retained, in cases where their services could be utilised to advantage. He imagined it would always be necessary under the Ministry of Supplies to maintain the combined Department.

MR. ROSE: Do I understand that the Ministry of Supply is to be a permanent Department? Is that the intention of the Government?

MR. HOPE: A Bill will shortly be introduced for that object.

Excess Profits Duty.

On Monday MR. CHAMBERLAIN stated that the following regulation had been made under Section 40 (3) of the Finance (No. 2) Act, 1915:—

"The Commissioners of Inland Revenue shall, in addition to the powers conferred upon them by Section 40 (3) of the Finance (No. 2) Act, 1915, have power in any case to allow modification of the provisions of the 4th Schedule to the above-named Act owing to depreciation through effluxion of time of any capital which is employed in the trade or business and which is expended upon and consists of patent rights, so far as such depreciation is not offset by goodwill arising from the user of, or interest in, such rights. This Regulation shall have effect as from the commencement of the above-named Act."

Applications for a regulation were carefully considered on their merits. A regulation had been promised in connection both with the loss on realisation of stocks and in certain conditions with the loss of goodwill in the case of controlled establishments. With the exceptions referred to above, the circumstances put forward in connection with the applications which had hitherto been made had not been such as to justify the making of a regulation.

Wages (Temporary Regulation) Extension.

A Bill has been introduced to extend the operation of the Wages (Temporary Regulation) Act, 1918, for a further period of six months, viz., till November 21, 1919.

Excess Profits Duty.

MR. GILBERT asked the Chancellor of the Exchequer on Wednesday whether a firm who made up its accounts for the year at March 31, 1919, would have to pay excess profit tax at the rate of 80 per cent. for three-quarters of the period, and 40 per cent. for the last quarter?

MR. CHAMBERLAIN: If the proposals relating to Excess Profits Duty, which are contained in the Budget Resolutions, receive statutory sanction in the forthcoming Finance Bill, excess profits arising in the accounting period of twelve months ended March 31, 1919, will be chargeable to that duty at the rate of 80 per cent. as respects three-quarters, and at the rate of 40 per cent. as respects one-quarter of such excess.

Excess Profits Duty.

THE CHANCELLOR OF THE EXCHEQUER stated in the House of Commons on Monday, in reply to a question by Mr. Kiley, that the Excess Profits Duty had now been in force for some five years, and he was not prepared at this date to introduce legislation which would have the effect of altering the whole scheme of the tax.

Health Conditions in Foundries.

On Monday, SIR R. HORNE informed Mr. Davison that regulations were made in 1908 to deal with injurious fumes which arose during the process of casting in certain brass foundries, and those regulations had had excellent results. No general representations as to unhealthy conditions in other classes of foundries had been received at the Home Office.

Restoration of Trade Practices.

SIR ROBERT HORNE, Minister of Labour, presented a Bill on Monday to make provision with respect to the restoration after the present war of certain trade practices and to amend the law relating to munitions tribunals.

British Key Industries.

SIR A. GEDDES assured Major Kelley, on Monday, that under the transitional trade policy of the Government most definite steps have been taken to protect the key industries of the country by retaining control over the importation of products similar to theirs.

Legal.

Non-Ferrous Casting Company v. Horton.

In the Chancery Division, on May 2, Mr. Justice Lawrence heard a motion by the Non-Ferrous Casting Company, Birmingham, to restrain E. N. Horton, Sheffield, from carrying on business in the same name as that of the plaintiff company.

Defending counsel said that he had offered to plaintiffs that if they would pay defendant £50 to cover his expenses for stationery, etc., and the costs of the action, the defendant would change his name to the Sheffield Ingot (Non-Ferrous) Casting Company.

Plaintiff's counsel said he would take an undertaking to change the name as suggested, ask for no costs, and treat the motion as the trial of the action.

His lordship considered the plaintiffs' offer a reasonable one, and after some discussion the motion was adjourned for a week in order that counsel might consult their clients.

Distribution of Surplus Assets.

Mr. Justice Astbury gave his decision on May 9 in the Chancery Division on a question submitted by the liquidator in the voluntary winding-up of Fraser & Chalmers, Limited. The issued capital of the company was £441,000, divided into 63,000 preference shares of £1 and 378,000 ordinary shares of £1. His Lordship was asked to determine upon what principle the surplus assets of the company which would remain after payment of the liabilities of the company, the costs of the liquidation, the capital paid up on the preference shares, the arrears of the preferential dividend and the capital paid up on the ordinary shares ought to be distributed. It was estimated that there would be a surplus of £150,000 in the hands of the liquidator. The question at issue was whether the preference shareholders were entitled to participate. His Lordship held that the surplus assets must be rateably distributed between the ordinary and preference shareholders.

Commission on Excess Profits.

In the case of the Patent Castings Syndicate, Limited, v. Etherington, the defendant appealed from a decision of Mr. Justice Younger upon a summons taken out by the plaintiff company for a decision on the question whether, where, under an agreement, an employé is to receive a commission on the net profits of his employer, the excess profits duty paid by the employer ought to be deducted from the profits before arriving at the amount of the commission. The Judge held that the excess profits duty must be deducted before the net profits were ascertained, and their Lordships upheld this view, dismissing the appeal.

Trade Talk.

LAND is being cleared at Cowpen Square, Blyth, for the construction of a new shipyard.

FRICKER'S METAL COMPANY, LIMITED, have removed from Langley Street to Portland Road, Luton, Beds.

THE CHALMERS-EDINA COMPANY, manufacturers of pumps, etc., have removed to 39, Assembly Street, Leith.

MESSRS. SPOONER, SON & COMPANY, metal merchants, etc., have removed to Dashwood House, New Broad Street, London, E.C.

THE Institution of Wireless Engineers are applying to the Board of Trade for a licence to be registered with limited liability.

MILLWALL ENGINEERS' SUPPLIES, LIMITED, are being wound up voluntarily, with Mr. E. H. Clogg, 74, Coleman Street, E.C., as liquidator.

A STORE at Evelyn Street, Deptford, S.E., owned by A. and R. Mason, Limited, ironfounders, was severely damaged by fire on Tuesday.

THE WESTINGHOUSE ELECTRIC COMPANY, LIMITED, is being wound up voluntarily. Mr. A. E. Scanes, the chairman, has been appointed liquidator.

VICKERS, LIMITED, have appointed Messrs. D. Pyne and G. Deane, Commercial Union Buildings, Pilgrim Street, Newcastle, as their Newcastle agents.

THE MACHINE TOOL AND POWER MACHINERY ORDER, 1916, the Wood-Working Machinery Order, 1917, and the Treadle Lathes Order, 1918, have been suspended.

MESSRS. S. SHEPPARD, A. E. SHEPPARD and W. DAMPIER, brass and iron founders, trading under the style of Sheppard, Pettigrew & Company, have dissolved partnership.

THE GENERAL ENGINEERING COMPANY (HORNSEY), LIMITED, is being wound up voluntarily, with Mr. T. Greenhill, 52, Queen Victoria Street, London, E.C., as liquidator.

ACCORDING to the "Echo de Mines" of May 25 (Sunday), the official decree issued during the previous week still upholds the embargo on exports of iron ore and bauxite from France.

MR. C. T. APPLEBY, 26, Corporation Street, Birmingham, has been appointed liquidator of Mitchell's Stampings, Limited, of Parr's Bank Chambers, 38, Waterloo Street, Birmingham.

THE blast furnaces and steel works of the Ebbw Vale Steel, Iron and Coal Company, Limited, have been closed in consequence of the shortage of coal, caused by the strike of Ebbw Vale miners.

AN application has been made to the Board of Trade for a licence directing the Women's Engineering Society to be registered with limited liability without the addition of the word "Limited" to its name.

THE business of gas and oil engine makers of Messrs. W. J. Bates & Company, of Crown Point, Denton, has been taken over by another concern, and extensions on a considerable scale are contemplated.

MESSRS. J. T. ROGERSON & SON, of Chicago, the well-known American stock-holding merchant iron and steel firm, are establishing a London office under the charge of Mr. A. L. G. Gentles.

A RECEIVING order has been made in connection with the affairs of Mr. J. F. Smith, carrying on business at 28½, Wrentham Street, Birmingham, and at Heath Street, Tamworth, in partnership as the Concast Metal Company.

MESSRS. A. C. DOO, D. A. V. RIST, and R. D. DOCKREE, engineers, 5a, Victoria Mews, New Southgate, London, N., trading under the style of the Crescent Manufacturing Company, have dissolved partnership.

WE understand that one of the principal Glasgow shipbuilding firms have acquired the engineering foundry of Messrs. Caird & Company, who recently became identified with the engineering firm of Messrs. J. G. Kincaid & Company.

MR. J. F. SMITH, carrying on business at 28½, Wrentham Street, Birmingham, and at Heath Street, Tamworth, in partnership, in the name of the Concast Metal Company, has been adjudged bankrupt. Mr. J. W. Blackham, 180, Corporation Street, Birmingham, has been appointed trustee.

THE CARDIFF CITY ELECTRICITY DEPARTMENT and the South Wales Electrical Power Distribution Company are arranging an exhibit of labour-saving devices at the forthcoming Royal Agricultural Show to be held in Cardiff from June 24 to 28.

FOR the week ending May 17, a basic furnace at the Lanarkshire Steel Company's works, Motherwell, operating on cold stock, produced eighteen charges, totalling 825 tons 2 cwts. The bath area of this furnace is 317 square feet. The same furnace yielded 732 charges in a single campaign.

MR. R. MILLETT, who was recently engaged for some years with Siemens Brothers' Dynamo Works, Limited, of Manchester, has been appointed by the Electric Construction Company, Limited, of Wolverhampton, as their sole Lancashire agent. Mr. Millett has opened offices at 30, Cross Street, Manchester.

A SERIES of lectures on "Industrial Administration," by Mr. E. T. Elbourne, will be given during June and July at Winchester House, Old Broad Street, E.C. The lectures will be divided into three courses, the first on "Factory Organisation," the second on "Labour Administration," and the third on "Factory Costing."

THE desirability of holding an exhibition in London next year of the manufactures and products of the Empire was discussed at a luncheon at the British Empire Club on Tuesday. The Dominions representatives having approved of the scheme, it was decided to approach the Government in order to get their approval.

THE Bessemer steel plant at the works of the Barrow Hematite Steel Company, Limited, which has been standing idle for the past four years, was put into operation again on Tuesday. Mr. J. Danks has been appointed manager of this department, succeeding Mr. T Blewitt, who has retired after 50 years' service with the company.

IT is stated that the scheme prepared by Palmers Shipbuilding & Iron Company, Limited, and placed before their employés to enable them to invest their savings in the new debenture stock of the company, and to which reference has already been made, has been favourably received. A large amount has been subscribed by the employés.

THE shareholders of Brett's Stamping Company, Limited, met on Tuesday in order to adopt a scheme for the capitalisation of undistributed profits. The total amount in hand is £35,000, and the board's proposal was to distribute £20,000 of it by way of bonus at the rate of one share for every one share now held. The necessary resolutions were carried.

THE marine machinery manufactured by Richardsons, Westgarth & Company, Limited, during the past year aggregated 235,000 horse-power, the number of ships engined being 51. These results exceed all previous records. The shops at Middlesbrough for the manufacture of shells have been closed down, but otherwise all the works of the company are fully employed.

MESSRS. J. D. D. DAVIS and W. L. Davis, partners in William Davis & Sons, iron, steel and metal merchants, Royal Metal Exchange, Swansea, have now been demobilised and have resumed business operations. Mr. E. H. Brooke, who has been carrying on the business during their absence, has relinquished the management and has moved into other offices in the same building.

THE Brazilian delegation, who are visiting this country on the invitation of the Federation of British Industries, will arrive in England about June 20. They will be staying in London for a few days before proceeding on their tour of the provinces. Members in the London district anxious to see or to show the

visitors over their works should communicate with the general secretary.

THE FEDERATION OF ENGINEERING AND SHIPBUILDING TRADES, after discussion of the Government's offer to sell the Chepstow and Beachley shipyards to the trade unions, finally declined to proceed with the negotiations to purchase. The opinion was expressed that the Government should continue possession of the national shipyards and develop public ownership and control of other national resources.

According to a statement prepared by the Statistics Branch of the U.S. War Department, the weight of steel projectiles fired by the Allies in 1918 was about 2,200,000 tons. This amounted to between 4 and 5 per cent. only of the total tonnage of steel ingots and castings produced in the United States either in 1916 or 1917. In the former year the output was 42,800,000 tons, and in the latter year 45,000,000 tons.

THE SOCIEDAD ESPANOLA DE CONSTRUCCIONES BABCOCK & WILCOX are making good progress with the construction of the new works which they are establishing in the Bilbao district. At the recent annual meeting it was stated that a further area of land had been purchased. The company has secured the licence for the sale and manufacture in Spain and Portugal of the productions of the British Mannesmann Tube Company, Limited, G. & J. Weir, Limited, and Lassen, Hjort & Menzies, Limited.

MR. H. C. J. CARRINGTON presided on Saturday last at the annual meeting of the Birmingham Association of Mechanical Engineers. Alluding to the forthcoming James Watt Centenary, the president commended the provisional scheme that had been adopted. Mr. E. E. Bissell was elected president for the ensuing session. Messrs. W. A. Jeboult and J. G. Walker were elected vice-presidents, Mr. Walter Deakin hon. treasurer, and Mr. F. W. Suffield hon secretary. A diploma for the best paper read during the session 1917-18 was presented to Mr. W. A. Jeboult.

IN connection with the Lyons Fair a committee has been appointed by British manufacturers and given full power to act on behalf of the exhibitors. The following gentlemen have been nominated, amongst others, on the general committee:—Major V. D. Amor Wilkins (Federation of British Industries), chairman, Mr. Neuts (Messrs. F. Marion & Company), Mr. Thynne (Canadian Export Association), Mr. B. Thomas (Messrs. Bertram Thomas, Manchester), Mr. J. Parker (British Rolling Mills, Birmingham), and Captain the Hon. C. Ashley (Association of Great Britain and France).

THE model village of Dormanstown, which is being built for the accommodation of the men employed at the Redcar Works of Dorman, Long & Company, Limited, from which works it lies about a mile to the south, is fast assuming considerable proportions. Already there are upwards of 270 houses finished and actually occupied, whilst 500 more are in course of building. An interesting innovation will be the erection of 12 houses with steel framing filled in with concrete. These are in the nature of an experiment which has been sanctioned by the Local Government Board.

THE President of the Board of Trade, after duly considering the recommendations of the Consultative Council on Imports, has given the following further directions in regard to the prohibitions of import:—Restrictions to be removed: Metal parts and accessories of pedal cycles, except those mentioned below; aluminium powder. Articles to be licensed only exceptionally, as and when required:—Gas stoves, metal parts of lamps, steel studs for motor-car tyres; metal parts and accessories of pedal cycles, frame lugs, hubs (including coaster hubs and hub shells), variable speed gears, free wheel clutches, cranks, pedals, rims, frames, forks, handlebars, chain wheels, bells, lamps other than electric lamps.

"UNITY," the organ of the National Alliance of Employers and Employed, offers prizes amounting to £200 (presented by Sir Robt. Hadfield, Bart.) for the best essay on either of the following subjects:—"A practical scheme for the joint development of industry by Capital and Labour;" "The most effective means for the prevention of unemployment;" "The most effective means for the prevention of industrial disputes." The committee of award will consist of the Right Hon. Fredk. Huth Jackson, P.C. (chairman of the National Alliance of Employers and Employed), the Master of Balliol College, Oxford, and Right Hon. Arthur Henderson, P.C.

THE WELLMAN SMITHOWEN ENGINEERING CORPORATION, LIMITED, has now been registered, with a nominal capital of £160,000 in £1 shares. As already announced, the company will take over and amalgamate all or part of the businesses of Wellman, Seaver & Head, Limited, the James Smith Hoisting Machinery Company, Limited, and Rubery Owen & Company, and will carry on the business of manufacturers of and dealers in engineering machinery, machine tools and instruments, etc. The first directors are Mr. A. E. Owen (permanent), Mr. F. I. Sanderson (commercial manager), Mr. J. Smith (managing director), and Mr. F. G. Smith (chief engineer). The registered office is at King's House, Kingsway, W.C.

THE 66th anniversary festival of the London Association of Foremen Engineers on Saturday attracted a record attendance, Mr. Douglas Vickers, M.P., presiding. Mr. T. J. Macnamara, M.P., paid a fine tribute to the work that engineers had done during the war. Speaking specially in regard to the Admiralty, their unprecedented output was attained at a time when extremely heavy calls were being made upon them for the repair of H.M.'s ships and of merchant ships, and in other departments of their work. He thanked them for the splendid way in which they had overcome all the problems which arose in connection with the war. The great effect of their work had been shown in everything affecting the prosecution of the war.

THE following headings have been deleted from the list of prohibited exports:—(A) Iron angles, channels, joists, tees and other sectional material; (A) iron bars, including flats, rounds and other sections and shapes; (A) iron bridgework, pierwork, and constructional material; (A) iron ingots; (A) iron plates and sheets; (A) rails; (A) sectional materials for shipbuilding; (A) steel containing tungsten or molybdenum; (A) steel containing chrome, cobalt, nickel, or vanadium; (A) steel angles, channels, joists, tees and other steel sectional material; (A) steel bars, including flats, rounds, and other sections and shapes; (A) steel bridgework, pierwork and structural material; (A) steel plates and sheets (except black steel sheets less than one-eighth of an inch thick).

THE directors of the Darlington Forge Company, Limited, propose to register a new company under the title of the Darlington Forge, Limited, with a capital of £1,500,000 in 750,000 7 per cent. cumulative preference shares and 750,000 ordinary shares of £1 each. Shareholders will be entitled to receive for each existing cumulative preference share of £1 each five 7 per cent. cumulative preference shares of £1 each, fully paid, in the new company, and for each existing ordinary share of £1 five ordinary shares of £1 each, fully paid, in the new company. This will leave 240,000 preference shares and 240,000 ordinary shares, which it is intended to leave unissued at present. It is also proposed to issue £400,000 debentures at 97½ per cent.

MR. H. LEE presided on Tuesday at the annual meeting of the Manchester Steam Users' Association, at which it was shown that during the year there had been an increase of boilers enrolled by 360, and at the end of the year the number was the highest on record. The revenue was also the highest yet attained; the net surplus was £732. The report was adopted on the motion of the chairman, who said that the year had been one of difficulty for all commercial concerns, and the Association had been no exception. It was founded

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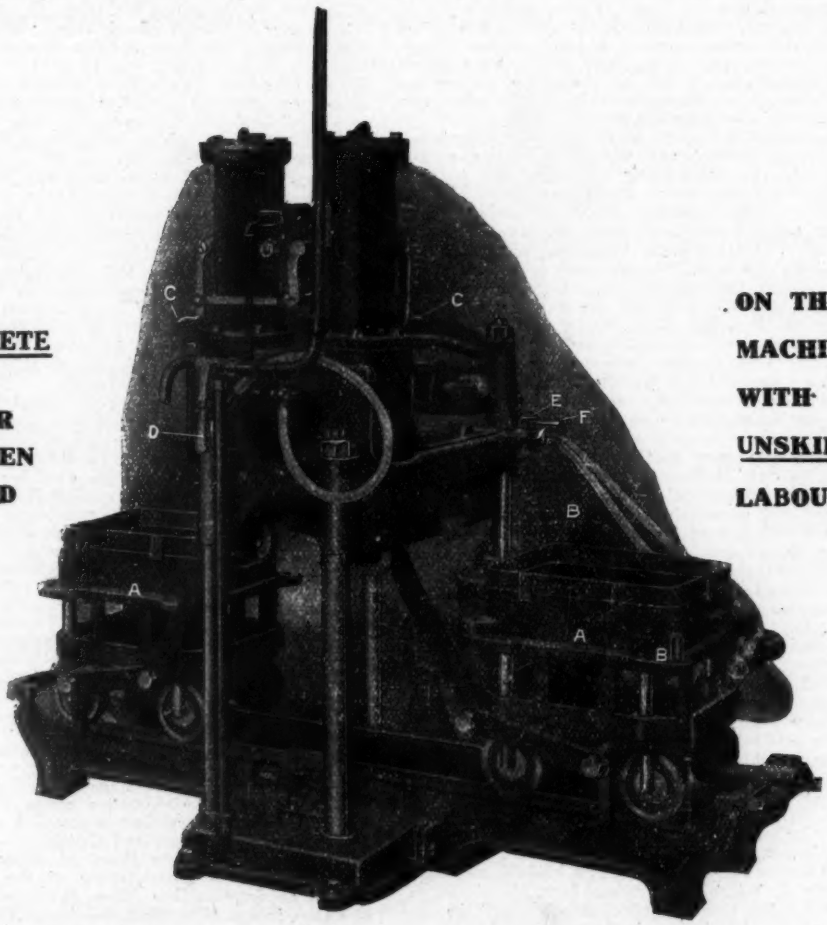

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not only to prevent explosions by careful inspection, but to promote economy in application as well as in steam-raising. With regard to trade prospects, he thought they might look forward hopefully, believing that as trade restrictions were removed and business freed from conditions made necessary by war, we should as a nation make progress, and still hold the foremost place we had held in the past.

THE output of steel from the works of the Parkgate Iron & Steel Company, Limited, last year, is practically equal to that of the previous year. The new blast furnace (No. 3) was started in July last, and is working satisfactorily. No. 1 blast furnace was blown out in July for relining, and will shortly be at work again. Good progress has been made with the new 400-ton metal mixer, and this will be ready for work in a few months. Work has been commenced on a new 24-in. section mill, which will be on the most modern lines and will replace the present out-of-date 20-in. mill. The directors propose, with the view of adjusting the capital account, to ask the shareholders' consent to the formation of a new company, bearing the same name, which will be forthwith registered, and having a capital of £1,500,000, which will be distributed among the shareholders in the Parkgate company in the proportion of three new shares for one existing share.

THE fourteenth annual meeting of the Birmingham Metallurgical Society was held on May 15, the chair being taken by the retiring president, Mr. Isaac E. Lester. The annual report stated that the past session had been a very successful one. The membership was now as follows:—Ordinary members, May 1919, 484; May, 1918, 328; student members, May, 1919, 65; May, 1918, 28; total, 549; previous year, 356, an increase during the year of 193. The following were elected as the officers of the Society for the ensuing year:—President, Mr. F. C. A. H. Lantsberry; Vice-Presidents: Messrs. A. Spittle, F. Johnson, H. B. Jacks, and A. J. G. Smout; Treasurer, Mr. J. Rogers, O.B.E. (re-elected); and Secretary, Mr. T. Vickers (re-elected). The recommendation of the Council that the Society be incorporated under the Companies Act was adopted, and the Council was authorised to take steps immediately to carry this into effect.

THE BRITISH INDUSTRIES FAIR (BIRMINGHAM) will be held on February 23 to March 5, 1920. The Fair will be held simultaneously with and will comprise groups of exhibits which do not clash with those of London or Glasgow. The classification of the trades which have been allotted will include the following, viz.:—Group I.—Class A.—Section 1.—Gas and electric fittings, etc. Section 2.—Cooking and heating appliances, etc. Class B.—Section 1.—Metal furniture, hollow-ware, copper goods and bronzes, etc. Section 2.—General hardware, tubes, pipes and fittings, etc. Group II.—Section 1.—Tools. Section 2.—Nautical scientific instruments and apparatus. Section 3.—Machinery belting of leather, etc. Section 4.—Scales, balances, and other weighing instruments, etc. Section 5.—Small machine tools. Section 6.—Ropes and cables. Group III.—Section 1.—Motor cycles, cycles, accessories, etc. Section 2.—Aeronautical motor appliances.

THE INTERIM INDUSTRIAL RECONSTRUCTION COMMITTEE for the zinc and spelter industry has been formed into a Joint Industrial Council, with the following officers:—Chairman, Mr. C. H. Eden; vice-chairman, Mr. J. Wignall, M.P.; secretary, Mr. C. Taylor, of the London Chamber of Commerce. At the first meeting in London, last week, the question of industrial diseases to which workers in this industry are liable was considered. Dr. T. M. Legge, of the Home Office, dealt particularly with the prevention of lead poisoning and Bright's disease. He stated that there had been a substantial reduction in the number of cases reported during recent years owing to the great structural improvements that had been made in the various works, but he admitted that the decline was much less than might reasonably have been hoped for, and he invited both sides in the industry to co-operate in reducing the causes of disease. He laid special stress on the vital importance of ventilation.

DURING their visit to Sheffield on Tuesday the King and Queen paid a visit to the Grimesthorpe Works of Cammell, Laird & Company, Limited, where the whole of the workpeople were given a holiday for the day. Their Majesties were received by the chairman of the firm, Mr. W. L. Hichens, who presented the following gentlemen connected with the establishment:—Mr. J. M. Allen, managing director; Mr. A. Good; Mr. L. Munns, secretary and director; Mr. W. Carnegie, manager of the Grimesthorpe Works; Mr. H. C. Loving, chief engineer; Mr. H. West, chief electrical engineer. The tour of the works then followed, and their Majesties displayed the keenest interest in all that was shown them. The managers of the various departments were presented to their Majesties, and answered a number of questions put to them by the Royal visitors. The following were presented:—Mr. F. Barson, Spring Dept.; Mr. G. A. Goodsall, Machine Shops; Mr. J. Russell, Forge Dept.; Mr. F. Naylor, Tyre Dept.; Mr J. Watson, Foundry; Mr. A. Weniger, Melting Dept.

THE BOARD OF TRADE have extended their general licence authorising, on certain conditions, the supply of goods to the territories on the left bank of the Rhine in the occupation of the armies of the Associated Governments, so as to cover, on the same conditions, the supply of goods to the occupied districts on the right bank. As regards both banks of the Rhine, applications should be made to the Export Licence Department, 4, Central Buildings, Westminster, S.W.1, in respect of goods remaining on Sections "A" or "B" of the Prohibited List, which it is desired to despatch to the occupied areas (including Luxembourg). Goods on Section "C" of the Prohibited List do not now require a licence for export to the above-mentioned territory, provided in the case of shipment via Holland, they are first consigned to the Standard Bank of South Africa, Rotterdam. Goods on the "free" list may continue to be exported free of all restrictions. No import permit from the authorities in the occupied areas is now necessary.

PALMERS SHIPBUILDING & IRON COMPANY, LIMITED, with the object of meeting the need for lodging and dining accommodation, have erected a large hostel and canteen mid-way between their Hebburn and Jarrow establishments. The hostel is composed of three large three-storey buildings, placed at the north, south and west boundaries of the site. The canteen, consisting of a large dining hall, kitchen, stores, offices, and staff quarters, occupies the middle and east portion of the site. There is also a laundry. The dining hall is connected to each hostel by a wide and well-lighted corridor. Ample air space has been arranged between the various blocks of buildings. These spaces form large courts, which are asphalted and can be used for games, etc. Besides these courts there is at the south end of the site a recreation ground for football and other games. In the hostel, accommodation is provided for 400 men, each man being given a separate bedroom. On each floor at the ends of each building two large sitting or recreation rooms are provided. Accommodation for washing is provided on each floor of each block in a separate building.

THE President of the Board of Trade, after duly considering the recommendations of the Consultative Council on Imports, has given the following further directions in regard to the prohibitions of import. The restrictions on the importation of the following goods are to be removed:—Certain agricultural implements; malleable tube fittings; pressure regulators, lubricators, grease cups, etc.; iron or brass expansion joints, pressed steel union couplings, water gauge fittings, steam traps, metallic steam packing; brass wire, copper wire, copper clad wire, phosphor wire, coppered steel spring wire, etc.; drop forged steel wire rope sockets; copper rods and steel and iron wire rods; antimony, crude, regulus and sulphide; gas irons; oil cans. The importation of the following articles is to be licensed'

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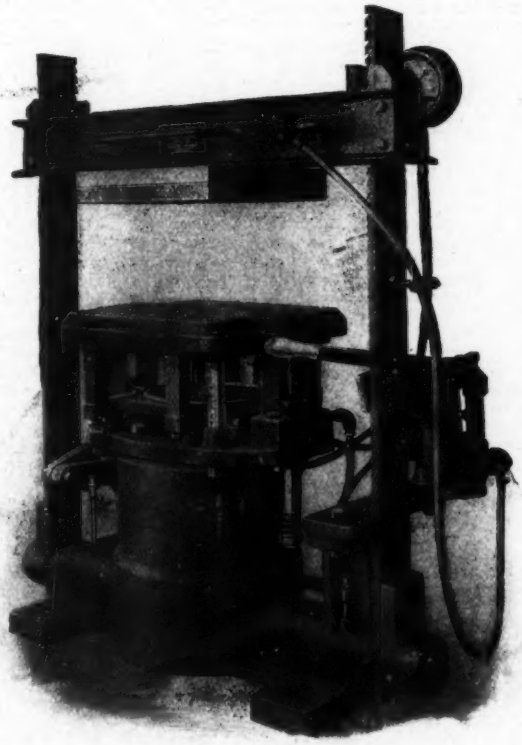

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only exceptionally, as and when required :—Chains; taper pins; brass rods, tape and strip, brass-coated tubes, brass or copper tubes and brass hose clamps; nickel wire, wire paper clips, wire nails and extras, barb wire, wire protector studs; horse shoe nails, wire shoe nails, wire hob nails, felt nails (iron or steel), cut nails (iron or steel); iron and steel valves, cocks for gas, water and steam and iron foot valves; steel and iron wire, wire bale ties and galvanised wire; miners' lamp glasses and miners' electric lamps. The importation of gun metal, brass or bronze valves for gas, water and steam, is to be restricted to a percentage of 1916 imports.

A CORRESPONDENT of the "Times" suggests the formation of an association of colliery managers to ventilate grievances and to secure higher rates of pay. He points out that the status and remuneration of all grades have been fully ventilated, with the sole exception of the sub-agents or managers. It is considered that the time has arrived when such managers should combine together in order that their conditions and salaries may be brought more on a par with those paid in other business industries, and that while it cannot be denied that a large number of owners have already been paying salaries in excess of the scales advocated, others have been much more parsimonious. It has been found that the Coal Controller has adopted a policy of keeping down the salaries of managers to as low a figure as possible, and in many cases has prevented owners from increasing salaries to the extent they desired. A strong combination of managers would soon remove such stumbling-blocks initiated by a Department which one day refuses an advance of £200 a year to a manager and next day gives away millions in advances to the workmen. Another important point is the constitution of the Coal Commission itself. On this owners, workmen, and consumers are fully represented, but the brains of the industry, as represented by general managers, agents, sub-agents, managers, and other officials, are altogether left out in the cold, and have no voice as to their own future, and that of the industry as a whole, except as witnesses, despite the great issues which are at stake and the fact that the bogies of nationalisation and executive dual control are still menacing them.

THE members of the Boys' Welfare Association met at the Central Hall, Westminster, on May 22, to discuss the enlargement of the scope of the association. Sir Wm. Beardmore, in moving the resolution, "That the objects of the association be extended to benefit, if so desired, all persons employed in industry," referred to the unsettlement in the labour world as a now outstanding problem of industry, the solution of which obviously lay in the revival of the old friendly relations between masters and men. The association had been warmly taken up by many of the leading firms of the country, and in spite of the disadvantages and uncertainty of the present day had made wonderful progress. There was at present, however, a danger of employers becoming confused between the various claims of the many agencies which had now taken up welfare work. Many employers, also, had come to the conclusion that it would be better for all workers to be dealt with together, and not separately. Further, there was little doubt the non-acceptance of the responsibility for the work by the employers themselves would lead to its being taken up by the State, with the inevitable chilling out of the human element. The council, therefore, after careful deliberation, had recommended the policy embodied in the resolution. Sir George Carter, K.B.E., of Cammell, Laird & Company, Limited, having seconded the resolution, it was put to the meeting, and carried, as also was a further resolution proposed by Mr. Hamilton (Fairfield Shipbuilding & Engineering Company, Limited) and seconded by Mr. S. Mavor (Mavor & Coulson, Limited) :—"That the constitution as now amended by the council be adopted." Under the amended constitution, the association will in future be known as "The Industrial Welfare Society."

THE Refractory Materials Committee of the Institution of Gas Engineers, in their report for the year, state that further reports are now ready on the crushing strength of bricks and also of their contraction, in which the effect of altering the proportion of grog and of its grain size on these properties is illustrated. Work on the thermal conductivity of bricks of different porosity has been resumed, and is now nearly completed. The action of reducing gases on fire-bricks has been the subject of much work which is not yet ready for report. Determination of the specific heat of silica materials at high temperature are also in progress. The experiments made to determine the deterioration of fire-bricks in prolonged use have so far yielded different results from what were anticipated. After twenty times heating for periods of eight days, during three of which the temperatures were in the neighbourhood of 1,280 deg. C., the bricks were practically as good as at the beginning. In some cases the bricks improved with the prolonged treatment, showing that some fire-bricks as turned out by manufacturers can be improved with a more severe burning. Arrangements are now being made to repeat these experiments under more drastic conditions. Preliminary experiments have been made in the purification of fire-clay by the "osmose" process. A very important work is the study of the best binding material for siliceous bricks and retorts. The experiments on the action of flue-dust show that the bond is first attacked. In the report presented to the Institution for 1917, reference was made to a movement for the formation of a Central Research Association representing all industries interested in the manufacture and use of refractory materials. The Committee formed for this purpose from the delegates of the Institutions and Societies concerned has not been able to agree on a basis of organisation satisfactory to all the industries concerned.

As indicated in our last issue a large public meeting representative of engineering in all its branches, and also the scientific institutions of the United Kingdom, was held in the Council Chamber, Birmingham, on Thursday, May 8, for the purpose of considering the provisional scheme for the celebration of the James Watt Centenary. The meeting was presided over by the Lord Mayor (Sir David Brooks), who was supported by Sir Oliver Lodge, Principal of the University of Birmingham, and Mr. Wm. Mills, Chairman of the Provisional Committee. The Lord Mayor, in opening the meeting, said it was a matter for surprise that, although so many books and articles had been written about Watt, and so many statues erected, no permanent memorial had been erected to one whose discoveries and inventions had probably exercised greater influence on the material progress of the world than the achievements of any other single individual. The Soho Foundry was known all over the world, and probably no other three men of such extraordinary capacities as Watt, Boulton and Murdock had ever been associated together. Their names would be inseparably linked for all time. The scheme must be of an international character. There could be no more fitting place for the erection of a lasting memorial than Birmingham, in which Watt spent the greater part of his life, and where—at Handsworth—his remains now rested by the side of those of his two former collaborators. The provisional scheme suggested the endowment of a Chair of Engineering at the Birmingham University, and also the erection of a Memorial Hall which should serve as a museum for bringing together examples of the work of Watt and his contemporaries and as a meeting place for the various technical societies. The scheme, which was outlined in our last issue, was approved and a committee was appointed with Mr. R. B. Asquith Ellis as hon. secretary. Mr. Dickinson, who represented the South Kensington Science Museum, said they had decided to hold a Watt commemorative exhibition in London. The international character of James Watt could not be too much insisted upon.

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Personal.

THE gross value of the estate of the late Mr. D. McCall, iron and metal merchant, of Blackheath, is £20,696.

MR. T. JONES, who was in charge of the export department of Baxendale & Company, Limited, Manchester, has retired after forty-eight years' service with the company.

THE Governors of the Imperial Mineral Resources Bureau have appointed Major W. M. Henderson-Scott to be secretary of the bureau in place of Mr. A. D. McNair, resigned.

THE late Mr. H. Berry, chairman and managing director of Henry Berry & Company, Limited, left property of the gross value of £202,087, of which £187,320 is net personalty.

MR. E. JONES has been awarded the Derby Gold Medal for his paper on "High Efficiency Air Pumps for High Vacua," read before the Liverpool Engineering Society during the year 1917-18.

MR. S. HEYWOOD, manager of the Waterside Engineering Works, Lincoln, of Messrs. Duckering & Company, has been appointed works manager to Messrs. Penney & Porter, Saxilby, Lincoln.

THE POSTMASTER-GENERAL has appointed Mr. W. Noble, assistant engineer-in-chief, to be engineer-in-chief to the Post Office, in succession to Sir William Slingo, who is retiring at the end of the present month.

MR. T. THOMAS, who has retired from the position of manager of Messrs. John Shearman & Company's ship-repairing business at Newport, has been the recipient of a presentation at a complimentary dinner.

MR. D. B. MORISON has been elected chairman of Richardsons, Westgarth & Company, Limited, in place of the late Mr. W. J. Richardson. Mr. R. S. Middleton, of Sunderland, has been elected a director of the company.

MR. H. H. WATSON, manager to Messrs. Matthias Spencer & Sons, Albion Steel Works, Arley Street, Sheffield, has been the recipient of a presentation from the officials and men, on his leaving to take up another appointment.

MR. T. E. CARR, the Wear delegate of the Boilermakers' Society, has been appointed chairman of the Wear Federation of Engineering and Shipbuilding Trades, and Mr. J. Grief, of the Patternmakers' Society, has been appointed secretary.

MR. G. AINSWORTH, J.P., who recently retired from the position of general manager of the Consett Iron Company, Limited, has been the recipient of a presentation from the members of the Foremen's Association connected with the firm.

MR. L. CHANDLER has resigned his position as managing director of the British Westinghouse Electric and Manufacturing Company, Limited, but retains his seat on the board. Capt. R. S. Hilton has been elected managing director of the company.

MR. V. S. WOODS, chairman of A. Ransome & Company, Limited, Stanley Works, Newark-on-Trent, has retired, and has been succeeded by Mr. L. Ransome. Mr. E. Edis, the secretary, and Mr. F. W. Baker, the London manager, have been elected directors of the company.

THE following have been elected to the London Metal Exchange Committee of Subscribers :—Sir C. L. Budd and Messrs. G. S. Smith, W. A. Tennant, W. Webb, G. Cawson, J. G. Weir, J. G. Buchanan, F. G. Martin, R. W. Rucker, F. D. Benjamin, F. C. Hill, S. O. Lazarus, A. S. Young, N. T. C. Sargant and W. E. Earle.

MR. A. B. SWEET-ESCOTT has been appointed general manager at Ebbw Vale. This appointment does not in any way interfere with the position of Mr. F. Mills as managing director, but has been made owing to the growth of the company's business. Mr. Sweet-Escott has been manager of Messrs. C. H. Bailey & Company's marine engineering works at Newport for a number of years past.

New Companies.

Machinery and Steels, Limited.—Capital £20,000 in £1 shares.

A.C. Cutting & Welding Company, Limited.—Capital £20,000 in £1 shares.

Hampton Engineering Company, Limited. — Capital £2,000 in 1s. shares.

Micro Gauge, Limited.—Capital £1,000 in £1 shares. First director : E. Sidwell.

Wests (Lincoln), Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers.

Metal Castings, Limited.—Capital £50,000 in £1 shares. Registered office : 30, Regent Street, W.1.

Victor Plating Company, Limited.—Capital £500 in £1 shares, to adopt an agreement with F. Walker.

Porter, Turk & Son, Limited.—Capital £12,000 in £1 shares, to carry on the business of ironfounders.

Self Engineering Company, Limited.—Capital £10,000 in £1 shares (5,000 7 per cent. cumulative preference).

Oscar Crane & Company, Limited.—Capital £5,000 in £1 shares, to carry on the business of brassfounders.

Norrington & Landon, Limited.—Capital £5,000 in £1 shares, to carry on the business of electrical engineers.

J. W. Bradley Small Tools Company (Leicester), Limited.—Capital £15,000 in £1 shares (10,000 preference).

L.M. Motors Company, Limited.—Capital £5,000 in £1 shares. Registered office :—10a, Victoria Street, Grimsby.

Granville Hawkins & Company, Limited.—Capital £20,000 in £10 shares, to carry on the business of engineers.

Robert Kellie & Son, Limited.—Capital £50,000 in £100 shares, to carry on business as engineers, brassfounders, etc.

Sanders Bros. & Company, Limited. — Capital £5,000 in £1 shares, to carry on the business of metal merchants.

John Coltman & Company, Limited.—Capital £5,000 in £1 shares (4,000 preference), to carry on the business of engineers.

John Manson Ramsay & Company, Limited.—Capital £20,000 in £5 shares, to carry on the business of iron and steel merchants.

Mechanical Products, Limited.—Capital £10,000 in £1 shares. Registered office : 37, Parkwood Road, Boscombe, Bournemouth.

S. Hinchcliffe, Limited.—Capital £5,000 in £1 shares to carry on the business of engineers. Registered office : 69, Mumps, Oldham.

Cyclops Engineering Company, Limited. — Capital £44,000 in 4.000 cumulative preference shares of £10 and 4,000 ordinary shares of £1.

Air Plants, Limited.—Capital £2,000 in 1,800 6 per cent. cumulative preference shares of £1 each, and 4,000 ordinary shares of 1s. each.

Millfords, Limited.—Capital £5,000 in £1 shares, to carry on the business of engineers. Registered office :—24, Bulloch Street, Birmingham.

John Birch & Company, Limited.—Capital £240,000 (£1 shares—60,000 preference), to take over the existing business of merchants and engineers.

W. H. Bird & Sons, Limited.—Capital £7,000 in £10 shares, to carry on the business of engineers. Registered office : St. Phillip's, Bristol.

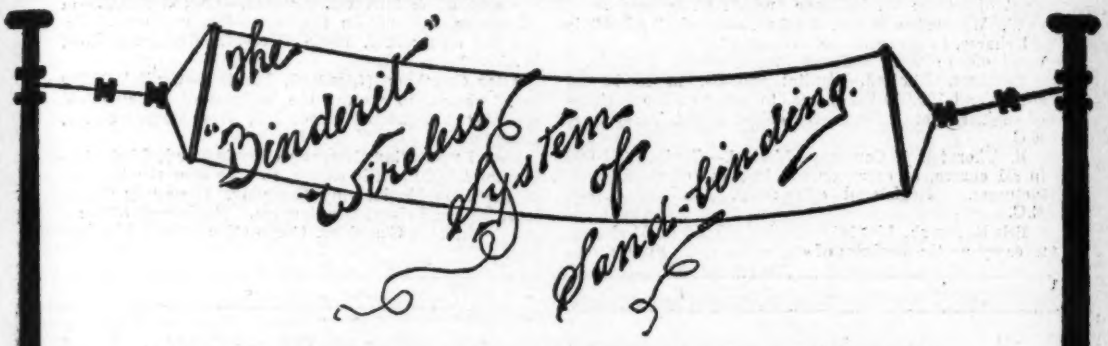
H. W. Jones, Limited.—Capital £10,000 in £1 shares, to carry on the business of engineers. Registered office : Parrin Lane, Monton, near Manchester.

Midland Pattern Making Company, Limited.—Capital £250 in £1 shares (150 preference). Registered office : Spring Gardens, St. Martin's Gate, Worcester.

Nurcads, Limited.—Capital £1,000 in 950 preferred ordinary shares of £1 each and 1,000 deferred of 1s. each, to carry on the business of engineers, etc.

F. L. Smidth & Company, Limited.—Capital £100,000 in £1 shares, to carry on the business of engineers, etc. Registered office : 20, Essex Street, W.C.

The Governing Director has now been invalided out of the Army from wounds, and Foundrymen can rely upon a constant supply of "Binderit" products at advantageous prices.



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The British Binderit Co. Specialise in those Requisites which are absolutely necessary for Successful Castings Production.

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"**BINDERIT**" Silicia or black-washes are of unrivalled excellence and superior to all others.

For Full Particulars and Prices apply to—

The British Binderit Co., Ltd.
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Binderit Trade Mark.

Telegrams:
"Bindercomp, Wands., London."
Telephone: 994 Putney.

Humphreys & Wyer, Limited.—Capital £20,000 in £1 shares, to carry on the business of ironfounders. First directors: W. Spowage and A. G. Spowage.

W. Warburton & Co., Limited. — Capital £5,000 in £1 shares, to carry on the business of engineers. Registered office: 43-5, Bedford Street North, Halifax.

Turbines, Limited.—Capital £20,000, in 10,000 £1 shares and 100,000 2s. shares, to carry on the business of engineers, etc. Registered office: 59, St. Mary Axe, E.C.

E. Thornton & Company, Limited.—Capital £10,000 in £1 shares, to carry on the business of steel manufacturers. Registered office:—39, Lombard Street, E.C.

Eric B. Marsh, Limited.—Capital £2,000 in £1 shares, to carry on the business of engineers, etc. First directors: E. W. S Bartlett, D. H. Marsh, and E. B. Marsh.

Goodchild & Partners, Limited.—Capital £30,000 in £1 shares, to carry on the business of engineers. Registered office: 56-8, Eagle Street, Southampton Row, W.C.1.

Allan Smethurst (Glasgow), Limited.—Capital £1,000 in £1 shares, to acquire the business of machine tool specialist. Registered office: 131, West Regent Street, Glasgow.

Lion Engineering Company (Birmingham), Limited.—Capital £5,000 in £10 shares, to take over the business of the Lion Engineering Company, Monastery Buildings, Upper Priory, Birmingham. Registered office:—16-17, Murdoch Chambers, Corporation Street, Birmingham.

The Five Essentials to Success

for a manufacturing establishment will, upon analysis, be found to be (1) Financial Stability, (2) Commercial Knowledge, (3) Accurate Accountancy, (4) Efficient Administration, (5) Technical Ability. Thorough mastery of the technical side is necessary, but is not always *the most important factor.*

Elbourne's "Factory Administration and Accounts" deals with the financial, commercial, accounting and administrative sides of factory management. It lays down the *principles* by which an industrial concern should be guided, as shown by the author's own experience with some of the most successful establishments in this country.

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Doubts and difficulties used by the multitude of advances and bonuses disappear, as by magic, from your office-routine when you instal the

UNIVERSAL WAGES CALCULATOR

The principle upon which this useful labour-saving device is constructed vanquishes the bugbear of sudden changes in working hours and percentage additions to standard rates. It gives maximum accuracy and speed with the minimum of work and no worry. To cover

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For all Soft Metals, Aluminium Alloys, &c.

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MONOMETER DIE CASTING MACHINE,
WHITE METAL MELTING FURNACE,
MOULD AND BEARING HEATING OVEN,
—— and TINNING FURNACE.——

We are also Makers of Crucible and Non-Crucible Furnaces in capacities from 30 to 1,000 lbs., and from 1,000 lbs. to 10,000 lbs., for all Ferrous and Non-Ferrous Metals, Steel, Malleable Iron, &c.

Sole Makers:—THE MONOMETER MANUFACTURING CO., Ltd., ASTON, BIRMINGHAM.

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(STOURBRIDGE) Ltd.,

STOURBRIDGE.

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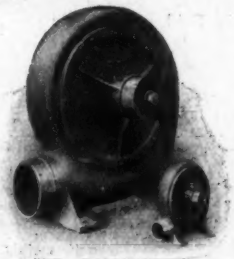

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Fans for Ventilation, for Dust Removal, for Induced & Forced Draft on Boilers.

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FANS

Cupola and Forge Fire Fans for large or small duties. Reliable and efficient.

Davidson & Co., Limited.,

Sirocco Engineering Works.

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GANISTER, CUPOLA BLOCKS, FIRE BRICKS,

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Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.

STEEL MOULDERS' COMPOSITION, SILICA CEMENT.

J. GRAYSON LOWOOD & Co., Ltd.,

DEEPCAR nr. SHEFFIELD.

Telegrams: "LOWOOD, DEEPCAR."

Deaths.

MR. T. MURCH, of Messrs. Murch Brothers, engineers, Littlehampton, Devon, died recently.

THE death is announced of Mr. J. Barker, manager to Henry Balfour & Company, Limited, Durie Foundry, Leven, at the age of 65 years.

THE death has taken place at Coatbridge of Mr. J. Crawford, formerly manager at the Moss Bay Works at Workington. The deceased was 68 years of age.

MR. J. H. PARKES, of A. & F. Parkes, Limited, manufacturers of edge tools, Birmingham, died recently as the result of an accident. He was 68 years of age.

THE death is announced of Mr. T. W. Wellsted, who had for about a quarter of a century been associated with the firm of Messrs. Bewick Moreing & Company, mining engineers.

MR. WILLIAM BOYD, first Mayor of Wallsend, and managing director of the Wallsend Slipway & Engineering Company, Limited, for 30 years, died on Monday at Cheltenham, aged 80.

THE death occurred recently of Mr. J. Reid, who was for many years works manager to W. H. Allen, Son & Company, Limited, Queen's Engineering Works, Bedford. He was 73 years of age.

THE death occurred recently of Mr. E. H. Pearce, of Messrs. Pearce & Sons, iron and steel merchants, Sheffield. The deceased gentleman, who was 75 years of age, had not taken any active part in the management of the business for several years.

MR. R. H. FOWLER, chairman of John Fowler & Company (Leeds), Limited, Steam Plough and Locomotive Works, Leeds, died recently aged 69 years. He had served for several years on the executive of the Engineering Employers' Federation.

NEWS has been received of the death of Mr. G. T. Barlow, C.I.E., Chief Engineer, United Provinces, Irrigation Branch, who, at the time of his death, was employed under the Government of India on a special survey of the hydro-electric potentialities of India.

MR. JOHN KELLETT, engineer and ironfounder, formerly in business in Clayton Street, Wigan, died at his residence at Southport on Wednesday of last week. The deceased gentleman, who was in his 84th year, was a younger brother of the late Mr. William Kellett, J.P., the well-known mining engineer.

Applications for Patents.

The names of communicators are printed in Italic type. A new number will be given when the Complete Specification is accepted.

Ballantine, W. B., and Sulman, H. L. Production of ferro-alloys. 11,668 May 9.

Berry, W. D. Copper alloy. 10,358. April 25. (United States, August 13, 1918.)

Bibb, D. H. Moulding machines. 10,614. April 29.

Bowen, C., and Marino, Q. Electrolytic process for coating iron or steel with lead or antimony or alloy of lead and antimony. 10,314. April 25.

Campbell, D. F., Campbell, Gifford & Waite, and Gifford, W. S. Control of power absorbed in electric furnace. 10,357. April 25.

Catterall, J. B., and Cohen, H. E. Furnaces for melting and refining metals. 12,907. 12,908. May 22.

Cooper, G. Means for casting tubes, etc. 9,802. April 17.

Courtot, L. Means for fixing foundry cores in moulds. 9,604. April 15. (France, February 7.)

Cunningham, D. M., and Stein & Atkinson. Furnaces for heat treatment of metals. 10,132. April 23.

Doehler Die Casting Company. Method of making finished castings. 11,770. May 10. (United States, November 30, '18.)

Green, G., and Roper, E. A. Foundry cupolas. 12,040 May 14.

Hyde, A. C. Means for electric welding of iron or steel or alloys thereof. 10,858. May 1.

Jackson, A. Production of iron. 10,333. April 25.

Keller, C. A. Manufacture of cast-iron. 12,293. May 15. (France, March 20, 1918.)

Lenoir, C. L. Manufacture of manganese and its alloys in electric furnaces 10,755. April 30. (France, January 8, 1914.)

Priest, C. F. Muffle and semi-muffle, etc., furnaces. 10,439 April 26.

Rennison, F. T. Reversible gas-heated furnaces. 10,307. April 25.

Sundberg, A. G., and Thomasson, T. E. Process for manufacturing pure electrolytic copper from cement copper. 11,312. May 6.

Sharp, A. (*Willmer*). Pots or crucibles for melting glass or metals. 10,145. April 23.

Speer, J. R. Chrome nickel steel. 10,338. April 25.

Stokes, F. W. Centrifugal moulding machines. 11,112. May 3.

Thomas, H. Furnace ladles. 12,131. May 14.

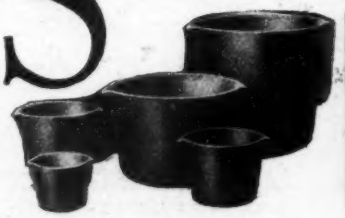
McKechnie Brothers. Method for separating or recovering nickel from cupro-nickel alloys, scrap, etc. 11,725. May 10.

T. E. MANSERGH.

EVERY DESCRIPTION OF
MOULDERS'
PATENT WOOD, MINERAL AND
COAL DUST BLACKINGS
MANUFACTURED.

Wheathill Charcoal Works, SALFORD.

SANKEY



Pressed Steel
FOUNDRY LADLES
Plain or Lipped

Let us know your requirements and we will quote you.

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Wellington — Shropshire

LEGGE'S IRON CEMENT.

The most efficient for general Engineering and Foundry Work.

It repairs permanently and effectively makes good all defects in Castings leaking parts and connections in Steam, Water, Gas and Air, etc.

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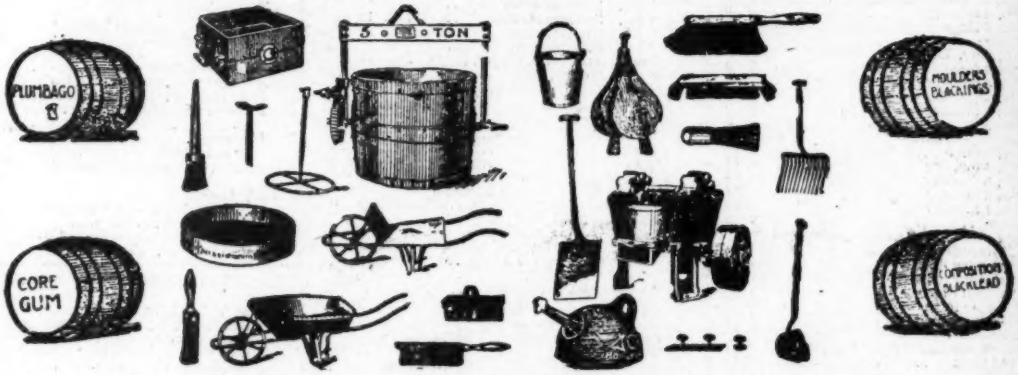
Telegrams: "Durrans, Pennistone." Telephone: 21, Pennistone.

Established 1863.

JAS. DURRANS & SONS,

Phœnix Works, Penistone, Near Sheffield.



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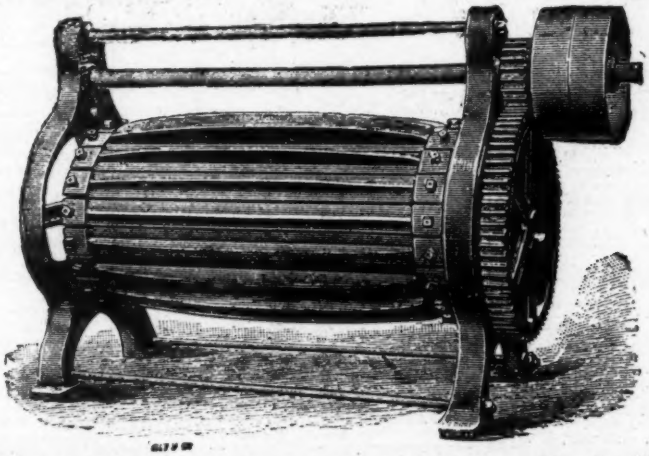
FOUNDRY EQUIPMENTS

COMPOSITION BLACK LEAD, PLUMBAGO, CORE GUM, WHITE DUST & COAL DUST

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, Etc.

Improved Foundry Rattler or Fettling Drum.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.

The following testimonial explains itself :—

"Dear Sirs,—We have been using your best Blacking for a large number of years, and always use it on our large Ingot Moulds, which, as you know, we have made up to 85 tons in weight.

Yours faithfully, THE BRIGHTSIDE FOUNDRY & ENGINEERING CO., LD.

MONTHLY PRICE LIST.

The undermentioned prices, unless otherwise specified, are those obtaining at the commencement of the current month.

CONTROL PRICES.

Pig-Iron.

	Home. £ s. d.
Hematite—	
East Coast Mixed Nos.	9 10 0
East Coast No. 1	9 12 6
West Coast Mixed Nos. £8 17 6–9	8 0
Scottish Mixed Nos. ..	£9–£9 5 0
Welsh Mixed Nos	9 15 0
Cleveland—	
No. 1	8 4 0
No. 3 foundry G.M.B.	8 0 0
No. 4 foundry	8 0 0
No. 4 forge	7 17 6
Basic	8 5 0
Derbyshire, Leices., and Notts—	
No. 4 forge	7 0 0
No. 3 foundry	7 2 6
No. 2 foundry	7 4 6
No. 1 foundry	7 6 6
Basic	7 7 6
Northamptonshire—	
No. 4 forge	6 12 6
No. 4 foundry	6 15 0
No. 3 foundry	6 15 0
No. 2 foundry	6 17 0
No. 1 foundry	6 19 0
Basic	7 2 6
South Staffordshire, Shropshire and Worcestershire—	
Part-mine forge	7 10 0
Part-mine foundry	7 12 6
Common Staffs.	7 5 0
All-mine forge	8 5 0
All-mine foundry	8 10 0
Warm-air forge	9 15 0
Warm-air foundry	10 5 0
Cold blast	12 10 0
Basic	7 7 6
Scottish—	
Foundry	8 9 0

NOTE.—The above prices are those fixed by the makers as a minimum for May-June delivery. In consequence of works being booked to capacity, makers are now quoting on an average 5s. per ton higher.

Delivered in Manchester—	
*Derbyshire, No. 3	8 7 6
*Cleveland, No. 3	8 12 6
*Scottish, No. 3	9 11 0
* Merchant prices.	
Delivered in Sheffield—	
East Coast hematite	9 10 0
Derbyshire basic	8 10 0
Lincolnshire basic	8 7 6
Do. No. 3 foundry	7 12 6
Do. forge	7 10 0

High-Speed Tool Steel.

	s. d.
Finished bars, 14 per cent. Tungsten ..	2 11
Finished bars, 18 per cent. Tungsten ..	3 6
Per lb. delivered buyers' works.	
Extras—	
Rounds and squares 3 in. to 8 in. inclusive	4d. per lb.
Rounds and squares under ½ in. to ¼ in.	3d. ,,
Flats under 1 in. by ½ in. to ¼ in. by ¼ in., and all sizes over four times 3 in width and over thickness ..	3d. ,,
Bevels of approved sizes and sections	6d. ,,
If in Coils	3d. ,,
Packing	4s. per cwt
Bars cut to length	10% extra
Scrap from High-Speed Tool Steel—	
Scrap pieces, 5d.	
Turnings and Swarf, 3d.	
Per lb. net, d/d steel-makers' works.	

Ferro-Alloys

Ferro-Titanium.—15/18% Ti. and 5/8% car., 8d.
Ferro-Titanium.—23/25% Ti. carbonless, 1/6.
Ferro-Tungsten.—80/90%, 8/–.
Ferro-Molybdenum.—65/80%, Mo., 13/–.
Ferro-Vanadium.—33/40%, Va., 25/–.
Metallic-Manganese.—90/95%, carbonless, 3/6. (All per lb.).
Ferro-Phosphorus, .—20/25%, P. £21 0 0.
Ferro-Chrome.—4/6%, car., £55 0 0.
Ferro-Chrome.—6/8%, car., £52 10 0.
Ferro-Chrome.—8/10%, car., £51 0 0.
Ferro-Chrome.—Specially refined, basis 60% chr., max. 2% car., £49 0 0.
Ferro-Silicon.—75% Si., £40 0 0.
Ferro-Silicon.—45/50% Si., £25 0 0 d/d. at Sheffield Steelworks.
Ferro-Manganese.—80%, £25 loose, £26 0 0 packed. Export £25, according to destination. (All per ton.).

Copper.

	£ s. d.	£ s. d.
Standard cash	84 5 0	84 10 0
Three months	85 0 0	85 5 0
Electrolytic	86 10 0	88 10 0
Tough	86 10 0	—
Best selected	87 0 0	88 0 0
Sheets	117 0 0	—
India	116 0 0	..
American electrolytic spot	87 0 0	—
Do. June	86 10 0	—
Do. July-August ..	86 10 0	—

Official average price cash, May	77 16 7 3/5
Do. Three months, May ..	78 0 4 1/5
Do. Settlement, May ..	77 16 1 1/5
Do. Electro, May ..	81 11 9 3/5
Do. B.S., May ..	81 13 10 1/2
Average spot price, copper, May	77 14 10 1/2
Do. Electro, May	86 3 7 1/2

Tin.

	£ s. d.	£ s. d.
Cash	243 0 0	243 10 0
Three months ..	239 0 0	239 10 0
English	239 0 0	240 0 0
Bars	241 0 0	242 0 0
Refined	..	—
Straits	245 0 0	—
Australian	..	235 0 0
Eastern	..	—
Banca	..	—

Official average price, cash, May	234 9 5 3/5
Do. Three months, May ..	231 14 2 1/5
Do. Settlement, May ..	234 7 0 1/5
Average spot price, May ..	234 7 8 1/2

Spelter.

	£ s. d.	£ s. d.
Ordinary	36 15 0	—
Remelted	36 10 0	37 10 0
Hard	27 10 0	28 0 0
Electro 99.9 ..	40 0 0	41 0 0
English	38 0 0	—
India	35 10 0	36 10 0
Zinc dust	60 0 0	70 0 0
Do. English	70 0 0	—
Zinc ashes, per cent. 70	12 0 0	13 0 0
Official average price, April	..	35 13 9
Average spot price	..	35 10 0

Lead.

Soft foreign (net)	23 0 0
English	24 0 0
Official average price, May	23 18 5 1/2
Average spot price, May ..	23 17 3 1/4

Antimony.

English regulus	45 0 0
Chinese	41 10 0
Crude	32 0 0
Ore	Nominal.

Aluminium.

Virgin Metal 98/99—.. .. .. 150 0 0 per ton.

Phosphor Bronze.

INGOTS.	Per ton.
Alloy No. I. or II.	—
III., IV., or V.	—
IV. or VII	—
VIII.	—
XI.	—
Cast Strips and Ingots	—
CASTINGS.	Per lb.
I. or II.	—
III., IV. or V.	—
IV. or VII.	—
VIII.	—
XI.	—
No. VII., Chill, Cast, Solid	—
,, Cored Bars	—

Delivery 2 Cwt. free to any town.
10 per cent. Phosphor Copper price of best selected copper. .. £40 above
15 per cent. Phosphor Copper price B.S. .. £60 above
Phosphor Tin (5 per cent.) price of English Ingots. .. £20 above
Phosphor-bronze prices supplied by CHARLES CLIFFORD AND SON, LIMITED, FAZELEY STREET MILLS, BIRMINGHAM.

*Chromium (Metallic).

98/99— purity, per lb. — —

*Nickel.

In cubes, 98/99— purity per ton .. £195 0 0

Nickel Silver.

	per lb.
Ingots for raising	1/4 to 1/9
Ingots for Spoons and Forks	1/4 ,, 1/9
,, rolled to spoon size ..	1/6 ,, 1/11

*Tungsten Metal Powder.

	per lb.
96/98— purity, per lb.	3/6

*Molybdenum Metal.

96/98,— purity per lb. .. .. —

*Cobalt Metal.

	£ s. d.
97— purity, per lb.	0 12 6

Quicksilver.

75 lb. bottle	18 5 0

* Net, delivered Sheffield Works.

Scrap Iron and Steel.

Cleveland.	s. d.	s. d.
Steel scrap, heavy melting	—	—
Iron scrap cast (cupola metal) ..	—	—
(London f.o.b.).		
Heavy steel		127 6
Light ,, ...		80 0
Heavy cast		120 0

Steel Scrap.

Without Analysis—	Per ton. £ s. d.
Heavy steel melting scrap	6 15 0
Steel planings, turnings and borings	4 15 0
Steel planings, turnings and borings mixed with wrought-iron or other material	4 0 0
Other classes of steel scrap, whether or not mixed	6 5 0
F.o.r. or in barge at nearest siding or wharf.	
With Analysis—	
Heavy steel melting scrap not over 0.04 per cent. p. and s.	7 10 0
Heavy steel melting scrap not over 0.05 per cent. p. and s.	7 5 0

Wrought-Iron Scrap.

	£ s. d.
(1) (a) W.I. plates and sections, not less than ⅛ in. thick, reasonably clear of rivets, flanged ends, etc., suitable for shearing · cable scrap and chain scrap not less than ¼ in. dia.	7 17 6
(b) Heavy W.I. scrap not less than ¼ in. thick including horseshoes, rivets and bolts, and scrap therefrom	7 17 6
(c) W.I. scrap under ¼ in. thick, and all W.I. scrap not included in classes 1, 2 and 3	7 17 6
(2) Mixed W.I. scrap	6 7 6
(3) Wrought-iron planings, turnings and borings mixed with steel or other materials	4 2 6
(4) W.I. planings, turnings and borings	4 17 6

Cast-Iron Scrap.

	£ s. d.
Heavy ord., broken, between 1½ cwt. and 10 cwt. each	6 15 0
Heavy machinery, broken between 1½ cwt. and 10 cwt. each ..	7 0 0
Cold blast, broken, between 1½ cwt., and 10 cwt.	8 15 0
Ingot-mould, unbroken	8 0 0
Do. broken, between 5 cwt. and 2 tons each	8 5 0
Do. between 1½ cwt. and 5 cwt. each	8 10 0
Railway chairs, whole or broken for remelting	7 0 0
Heavy lumps, not exceeding 2 tons each	6 12 6
Light	6 5 0
Burnt, broken ready for cupola ..	5 10 0
Burnt fire bars	6 0 0
Turnings and borings, for iron and steel makers	5 5 0

Old Metal.

London—	£ s. d.
Copper (clean)	72 0 0
Brass (clean)	50 0 0
Lead (less usual draft)	19 0 0
Tea lead	18 0 0
Zinc	24 0 0
New aluminium cuttings	95 0 0
Braziery coppper	60 0 0
Gunmetal	74 0 0
Hollow pewter	160 0 0
Shaped black pewter	110 0 0
(Above all d/d merchant's yard).	

Metallurgical Coke.

Durham and Northumberland—	£ s. d.
Blast furnace	1 19 0
Foundry	2 4 0
Lancs., Staffs., Yorks., Notts., Derbyshire, Lincolnshire and Midland Counties—	
Blast furnace	2 2 0
Foundry	2 16 0
F.o.t. at ovens.	

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FOUNDRY FOREMEN wanted. Heavy and light green sand work—about 30 tons per week. Good salary to first-class man well up in modern practice. References, experience and salary required to Barford & Perkins, Limited, Peterborough.

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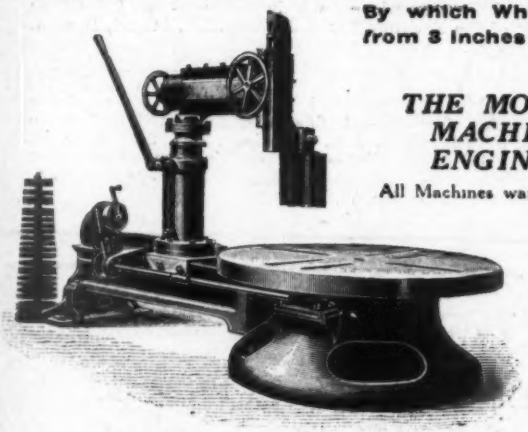

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